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PAINTED ROCKS DAM
(Also Known As West Fork of the Bitterroot Dam)

MANUAL FOR OPERATION AND MAINTENANCE

State Water Projects Bureau
Water Resources Division
Department of Natural Resources and Conservation
48 North Last Chance Gulch
P. O. Box 201601
Helena, MT 59620-1601

Initial Publication September 1998
Revised December 2001

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PROJECT DESCRIPTIPON

OVERVIEW

Painted Rocks Dam, also known as West Fork of the Bitterroot Dam, is located on the West Fork of the Bitterroot River in Ravalli County. The project is approximately thirty miles southwest (upstream) of the town of Darby, Montana (see Figures 1 and 2). Figure 3 provides a general layout of the dam, spillway and outlet works.

The dam is owned by the Montana Department of Natural Resources and Conservation (DNRC) and is managed by the State Water Projects Bureau (SWPB) of the DNRC. The DNRC Missoula Regional Office (MRO) manages and operates the dam. The Painted Rocks Water Users Association (herein called the "association") is responsible for repairs and maintenance of the dam.

Water from the reservoir is primarily used for irrigation and fisheries water supply. The reservoir also is used for water based recreation and the regulation of instream flow rates.

EMBANKMENT

The curved-axis earth filled dam was completed in 1939. The dam is 143 feet high and 800 feet long. The crest width varies from 20.5 to 35.5 feet. The dam has a bridge over the spillway and a road across the top the dam embankment for access to U.S. Forest Service property.

OUTLET WORKS

The outlet works which consists of an intake structure, tunnel conduit, and a wet-well tower is located in the right abutment of the dam. The intake structure consists of a 30-foot high concrete tower with trash racks on the tower top and on three sides. The concrete lined tunnel is a 10-foot diameter horseshoe shaped section approximately 580 feet long. The upstream 206 feet of the tunnel is founded on gravel and decomposed granite, and the remaining 374 feet go through granite. A wet-well gate tower is located about 340 feet downstream from the intake structure near the centerline of the dam. The wet-well contains two 5 ft. X 8 ft. roller gates (one operating gate and one emergency gate) with controls located at the dam crest. The gates are operated by a cable hoist mechanism powered by an electric motor located in the gatehouse at the top of the control tower. There are also two air vents (6 inch and 42 inch diameter).

In 1977 and 1978, the outlet was reconstructed below the operating gate to prevent cavitation in the tunnel. A new 42-inch diameter air vent was constructed. The sides of the gate chamber below the gate were made straight and vertical, the floor was constructed as a ramp, and ¾ inch steel plates cover the sides and bottom. At the downstream end of the ramp section, the floor drops vertically to the tunnel floor. A steel pipe was added below the transition and extends to the top of the air vent structure so that the difference in air pressure can be measured to get an estimated flow through the gate. The use of the pressure gauge is very difficult and is not used.

The air vent was constructed in 1978 and has a 42-inch diameter corrugated pipe incased in concrete with a rectangular concrete air vent structure placed on top of the pipe. The air vent structure has a transition section from square to circular. Steel grates were placed on all four sides of the air vent structure with a manhole door on the top.

SPILLWAY

The spillway, located in the right abutment, is founded in granite rock for its entire length. The unlined approach channel to the uncontrolled concrete ogee-shaped crest is approximately 100 feet long and is crossed in front by a log boom. The crest discharges to a concrete chute, which ends in a stilling basin about 10 feet below creek level.

The concrete crest is formed in an ogee shape with approximately 12-foot of design head. The spillway crest is 160 feet wide and contains two 2.5-foot-wide bridge piers, which reduces the net spillway width to 155 feet. The spillway narrows from the 160 feet at the top to 60 feet at the bottom where it enters the stilling basin.

The stilling basin is lined with concrete and is about 150 feet long. The stilling basin floor is at two elevations; the 52-foot length nearest the spillway is 10 feet lower than the stream channel, and the remaining length is 4 feet lower than the stream channel. The width diverges from 60 feet to 125 feet. One row of chute blocks is located at the end of the spillway chute, and three rows of baffle piers are located just down-stream in the stilling basin. The baffle piers are aligned towards the outlet tunnel where the outlet tunnel exits through the spillway face. A baffle wall crosses the stilling basin 52 feet downstream from the beginning of the basin, separating the two elevations of the floor. The wall is 11.5 feet high in the center and 9.5 feet high on each end. The sides of the downstream channel are heavily riprapped.

DRAINS

There are no drains at the dam.

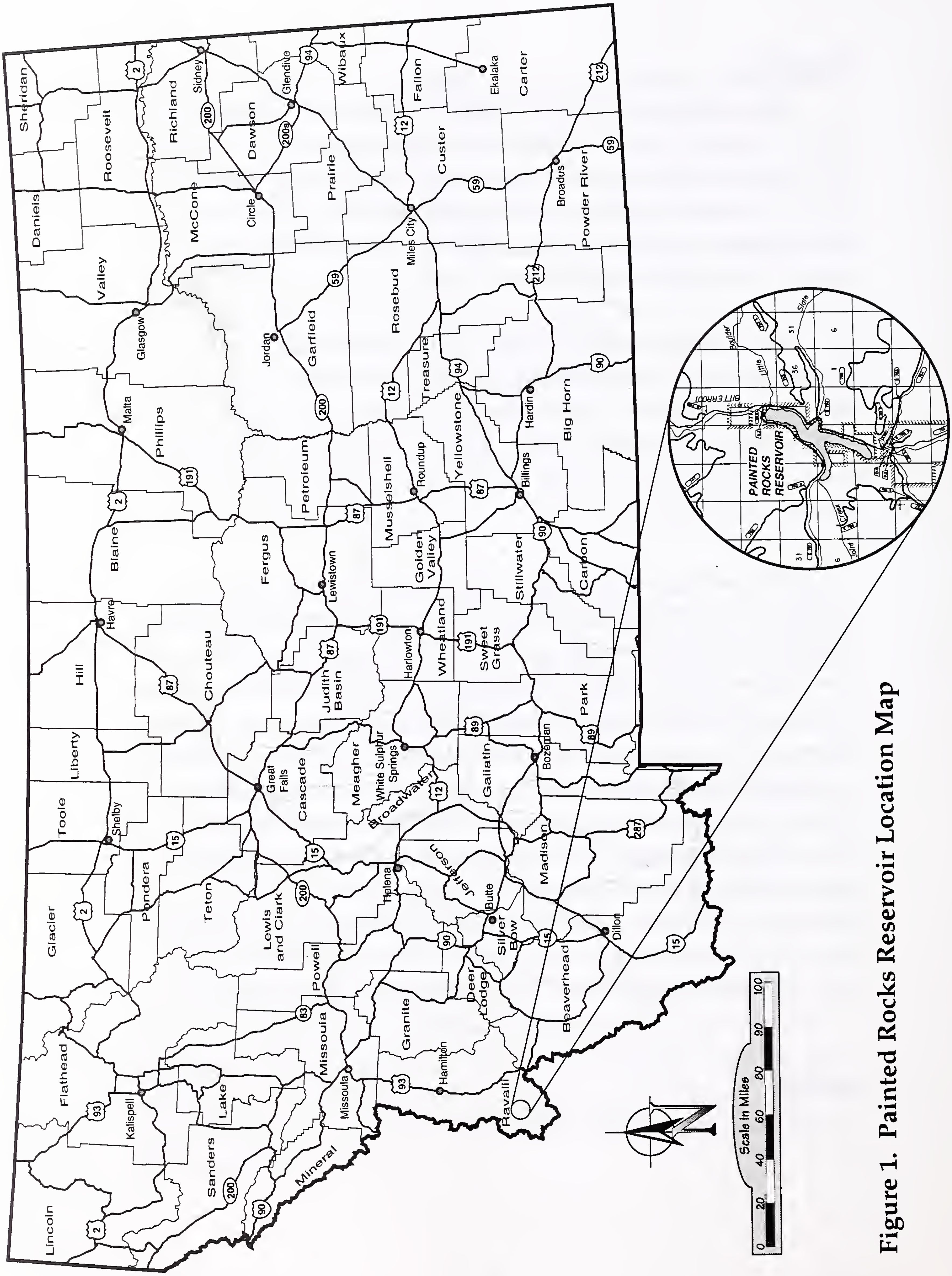

Figure 1. Painted Rocks Reservoir Location Map

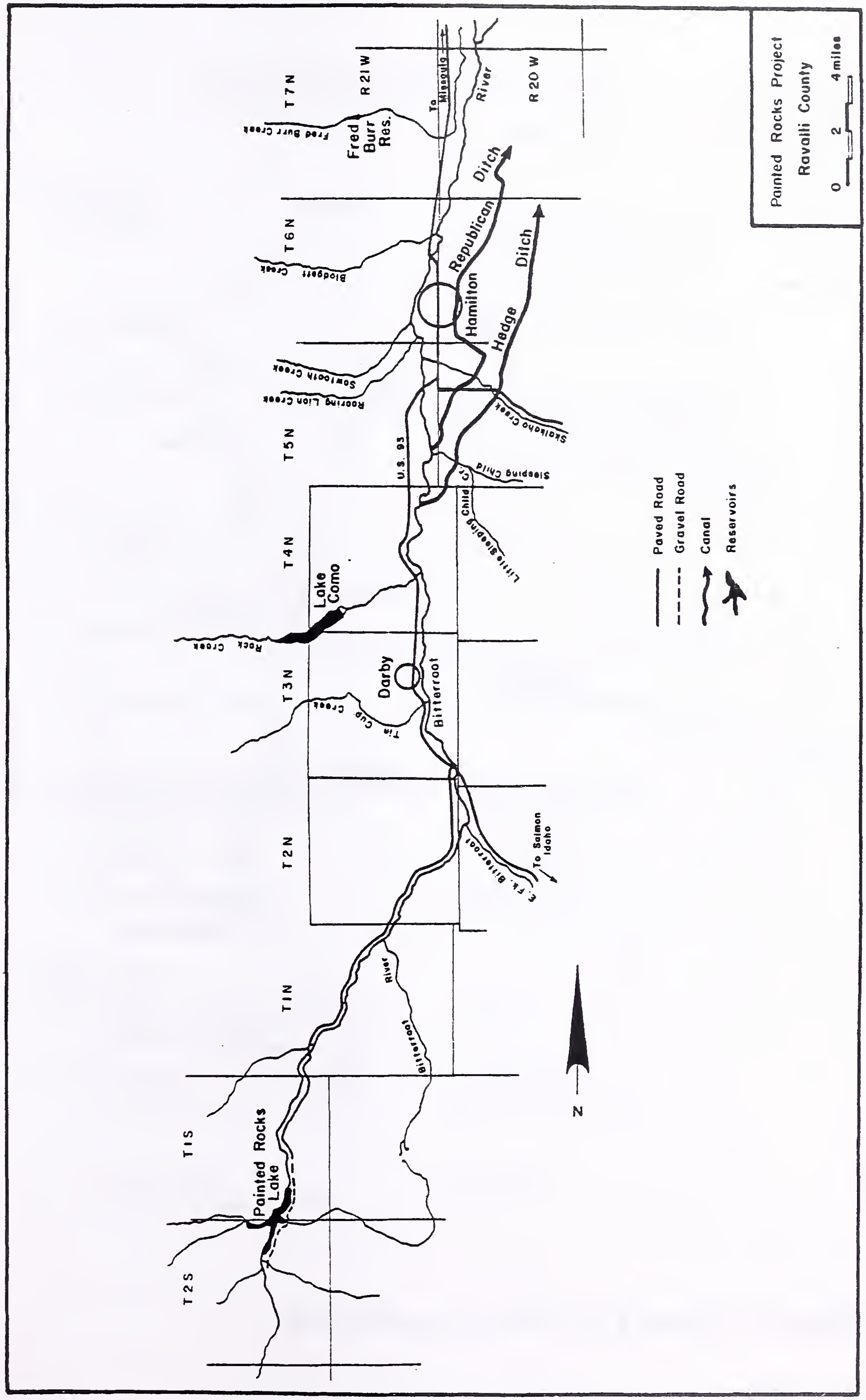

Figure 2. Painted Rocks Project Map

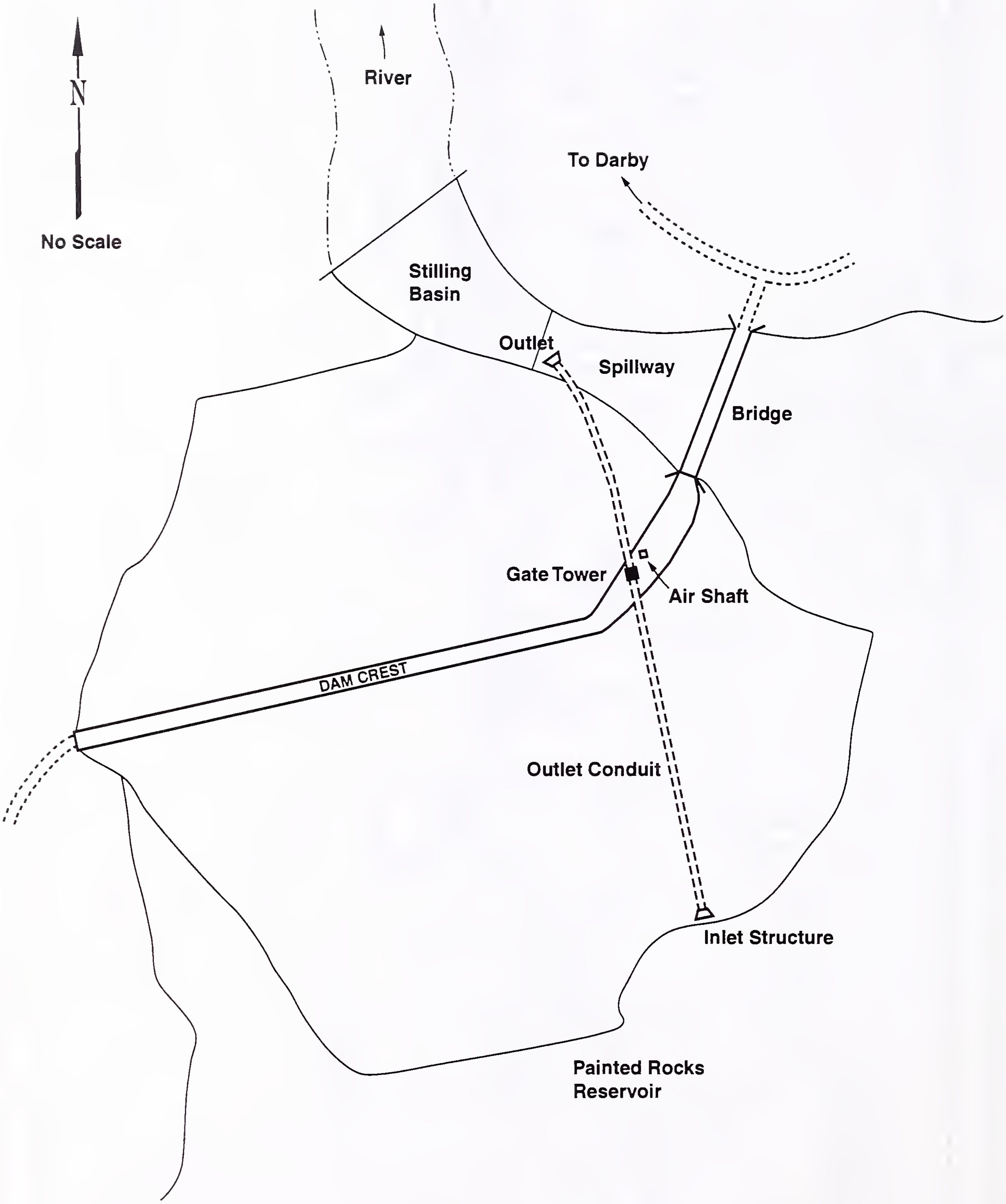

Figure 3. Painted Rocks Dam General Layout

STATISTICAL INFORMATION

1. General

a. Owner	Montana Department of Natural Resources and Conservation (DNRC)
b. Operator	Missoula Regional Office, DNRC
c. Location	Sections 26, Township 1 South, Range 22 West, Montana Principal Meridan, 30 miles southwest of Darby
d. Latitude	45° 43' 06"
Longitude	114° 16' 42"
e. County--State	Ravalli - Montana
f. Watershed Location	West Fork Bitterroot River, Clark Fork River Basin.
g. Drainage Area	316 square miles

2. Principal Elevations (feet above mean sea level)

a. Maximum Dam Crest	4,743.07 feet
b. Spillway Crest	4,725.5 feet
c. Normal Full Pool	4,725.5 feet

3. Reservoir

a. Length of Maximum Pool (approximately)	3 miles
b. Maximum Reservoir Level of Record (5/31/1995)	4,729.27 feet 34,322 acre- feet
c. Surface Area (at normal full pool)	655 acres

4. Storage

a. Total Storage (pool at dam crest)	45,100 acre-feet
b. Active Storage (pool at spillway crest)	31,706 acre-feet
c. Maximum Surcharge	13,394 acre-feet
d. Dead Storage (pool at invert of intake structure)	656 acre-feet

Note: Total storage, active storage, and maximum surcharge do not include dead storage.

5. Hydrology

a. Inflow Design Flood (Probable Maximum Flood -- PMF)	41,500 cfs
b. 100 Yr Flood	4,100 cfs
c. 500 Yr Flood	5,020 cfs

6. Embankment (Dam)

a. Type	Earthfill
b. Hydraulic Height	143 feet
c. Crest Length	800 feet
d. Crest Width	20.5 to 35.5 feet
e. Downstream Slope	1v on 2h (above elevation 4650.5 feet) 1v on 4h (below elevation 4650.5 feet and above elevation 4620.5 feet) 1v on 1.5h (below elevation 4620.5 feet)
f. Upstream Slope	1v on 2.5h (above elevation 4650.5 feet) 1v on 4h (below elevation 4650.5 feet)

7. Outlet Works

a. Size	10-feet diameter, horseshoe-shaped reinforced concrete tunnel
b. Length	580 feet
c. Gate	Two 5-foot by 8-foot roller gates (one operating gate, one emergency gate) located at the bottom of a vertical wet tower
d. Control	Gates controlled by electric motor pulley system with cables from the dam crest
e. Capacity	
Pool at Dam Crest	3,300 cfs (approximate)
Pool at Spillway Crest	3,075 cfs (approximate)
f. Design Elevation	
i. Top tower grate (lower floor elevation)	4,729.9 feet
ii. Top Intake Structure	4,635.5 feet
iii. Inlet Invert Elevation	4,625.5 feet
iv. Conduit Invert Elevation	4,605.5 feet
g. Trashrack	Yes
h. Air Vent	6-inch diameter steel pipe exits inside gatehouse 42-inch corrugated metal pipe exits outside gatehouse.

8. Spillway

a. Location	Right abutment
b. Crest Elevation	4725.5 feet
c. Type	Uncontrolled concrete chute with ogee crest control
d. Width	160 feet at crest tapering to 60 feet
e. Capacity (pool at dam crest)	42,000 cfs

9. Tunnel Vent Shaft

a. Drill shaft	48-inch diameter
b. Shaft liner	42-inch corrugated metal pipe
c. Length	103.5 feet (+/-)
d. Top elevation	4466.0 feet (+/-)
Bottom elevation	4335.5 feet (+/-)
e. Vent structure	
Size	6-feet by 6-feet square by 10 feet high made of concrete
Top	Manhole door – Type 682 - Code No. 16441 – by Flockhart Foundry Co.
Vent opening	3.5 x 4 feet on each side

OPERATING PROCEDURES

Painted Rocks Dam is operated by the DNRC Missoula Regional Office (MRO). The primary operating goal of the reservoir is to provide an adequate supply of irrigation and fisheries water to meet contracts with water users without exceeding safe storage or flow levels.

DAM OPERATOR

The responsibility for the daily operation of the dam and reservoir rests with the SWPB and its dam operator. The dam operator is generally authorized to operate the reservoir to meet the SWPB's goals. The dam operator's specific responsibilities are to:

1. Operate the mechanical features of the outlet works
2. Coordinate filling of the reservoir and the release of water
3. Notify the SWPB of unusual occurrences such as impending floods, or excessive seepage.
4. Notify the SWPB when spring runoff flows have peaked and when water contract deliveries begin.
5. Perform maintenance tasks.

Typically, the out-going dam operator will train a new operator. The operator’s training focuses on the mechanical operation of the gates, measurement of the storage level, measurement of the rate of water release, and record keeping.

The dam operator normally is available to observe the dam and perform operating functions as needed during the irrigation season and when the Department of Fish, Wildlife, and Parks (DFWP) calls for their contract water. Communication between the dam operator and SWPB is by telephone. Although not routinely available, radio communication may be established during emergencies or unusual occurrences, so the dam operator can speak directly with the SWPB **(see the Painted Rocks Dam Emergency Action Plan)**.

METHOD AND SCHEDULE OF OPERATION

Depending on snowpack, runoff patterns, and carryover storage, filling the reservoir usually starts in April or May. The goal is to have the reservoir full before the main runoff has receded to a flow where all inflow must be allowed downstream to satisfy senior water rights.

The date irrigation releases begin varies from year to year. The water delivery contracts provide that water will be available to the users between the dates of May 1 and September 30. However, if water is available, water may be released outside the contract dates. Late April is the earliest month during which irrigation releases have begun. During typical years, releases begin around June 1 and end by mid-September. The actual dates that releases begin and end depend on each year's climatological and hydrological conditions.

Water is also released from the dam (during the same dates as the irrigation water) to help regulate instream flows for fisheries. These releases are dependent upon the yearly flow conditions in the Bitterroot River.

An Operating Plan for the Painted Rocks Reservoir has been adopted, dated March 30, 1999. The plan outlines general procedures for operating the reservoir so that the State can meet its obligations as provided in its Water Marketing Contract with the Painted Rocks Water Users' Association and its Water Purchase Contracts with the Montana Department of Fish, Wildlife and Parks. A copy of the plan is in Appendix A.

Maximum Winter Storage: The maximum reservoir elevation for winter storage is 4,693.0 feet with 14,947 acre-feet of storage. This winter maximum helps prevent damage to the riprap and embankment from wind-driven waves and ice.

Minimum Winter Storage: The minimum reservoir elevation for winter storage is 4,643.5 feet with 1,907 acre-feet of storage. This winter minimum helps prevent ice damage to the inlet structure for the outlet works, minimizes water quality problems, and helps to maintain the fishery.

Minimum Outlet Discharge: To help maintain the fishery in the West Fork Bitterroot River, the minimum outflow to be maintained at the dam outlet during the winter low flow period should be approximately equal to the inflow. In a normal year, the average outflow during the non-irrigation period is 80 to 90 cfs. Cutting outflows to below the minimum will be allowed only as needed to accommodate necessary dam safety inspections, maintenance, drought conditions, or other emergency purposes.

15,000 Acre-Foot Reservoir Level: When the reservoir storage level reaches 15,000 acre-feet, the DNRC will inform the water users so they may determine how to allocate remaining water contract releases before September 30. The DNRC has established a benchmark at this elevation. The benchmark is located 28 feet below the last ring on the boatramp.

September 30 Reservoir Level: The reservoir storage contents may not be drawn down below 6,700 acre-feet after September 30 in any given year. All contracts will be considered satisfied when the reservoir storage reaches this level.

GATE OPERATION

The maximum capacity of the outlet conduit with the reservoir at the dam crest is about 3,300 cfs. With the pool at the spillway crest, the capacity of the outlet works is about 3,075 cfs. The recommended maximum sustainable outflow through the low level outlet works is 500 cfs. This rate can be exceeded up to a maximum of 3,000 cfs for short periods of time.

The outlet gates consists of a cable hoist operating mechanism attached to steel gates with roller chains on each side. The gate hoists are operated by an electric motor and belts. If the electricity fails, the gates can be operated manually with a hand crank.

The gates are difficult to get closed. Jockeying the gates helps sometimes but not always. The gates normally stop moving when they are within 1 to 2 feet of the bottom (estimated).

The maximum gate opening for the operating gate is 8 feet. However, the gate should not be opened to the full height because the flow can cause sever damage downstream; unless an emergency exists where the full release is necessary. There is little problem in regulating large flows. However, trying to regulate small flows (less than 80 cfs) or closing the gates for inspection is where the operational problems occur. The emergency gate is normally stored at the top of the gate tower.

The outlet works are intended to be used for controlling the release of water for irrigation and fisheries, and not for providing emergency flood relief.

SPILLWAY

With the reservoir at the dam's crest, the maximum capacity of the spillway using a head-discharge relationship is 42,000 cfs. However, because the quickly converging chute may initiate wave action, the spillway chute walls may be overtopped at significantly less discharge.

A model study of the spillway and stilling basin was performed before construction. Based on the study, the spillway chute is capable of safely discharging 30,000 cfs. However, since the spillway can pass 42,000 cfs, a discharge of 40 percent greater than that model studies, it is likely the chute walls will be overtopped before this maximum discharge is reached. A rating curve for the spillway is included in Appendix B.

SAFE DRAWDOWN

To ensure stability of the upstream embankments, it is recommended that reservoir draw not exceed one foot per day. This recommended rate should not be exceeded without the approval of the SWPB.

STORAGE DETERMINATION

Reservoir storage is determined by taking slope measurements at the boat ramp located approximately 1/4 mile east of the dam. Measurements are taken on the upstream side of the concrete boat ramp. To determine the elevation of the reservoir surface and storage of the reservoir, measure in feet from the ring at the top of the boat ramp to the water surface (assumes water on boat ramp). If the water surface is below the boat ramp, measure in feet from the end of the boat ramp to the water surface). The elevation of the reservoir surface and the storage can then be found using the Slope Distance-Elevation-Storage tables (Table 1 or 2) in Appendix A.

INFLOW AND OUTFLOW MONITORING

Inflow Sites: Current inflows into the reservoir from West Fork of Bitterroot River, Overwhich Creek, Blue Joint Creek, and Slate Creek can be found using the staff gage at each site. A rating table for each site is found in Appendix A.

West Fork of Bitterroot River Site: The West Fork Bitterroot River gage site is located at the point where the river flows under the Coal Creek Road bridge. The staff gage is located on the left bridge pillar (looking downstream) on the downstream side of the bridge.

Overwhich Creek Site: The Overwhich Creek gage site is located where the creek flows under the West Fork road. The staff gage is located directly below the downstream side of the bridge and adjacent to the left bank (looking downstream) behind a 3-foot size boulder in the stream bed.

Blue Joint Creek Site: The Blue Joint Creek gage site is located where the creek flows under the Little Blue Joint Creek road. The staff gage is located on the left bridge pillar (looking downstream) on the upstream side of the bridge.

Slate Creek Site: The Slate Creek gage is visible from the West Fork road where it crosses the mouth of Slate Creek. The staff gage is located approximately 250 feet above the county road on the right bank looking downstream. Access is through the Forest Service Campground road.

Outflow Sites: Current outflows from the reservoir and flows in the Bitterroot River can be found under the Clark Fork River Basin portion of the following USGS internet site:

http://mt.waterdata.usgs.gov/nwis/current?type=flow

USGS gage 12342500, West Fork Bitterroot River near Conner, MT: This gage can be used to monitor the outflow from the dam. The gage is located on the right bank 0.6 miles downstream from the dam. The drainage area is 317 sq. mi. and the period of record is from April 1941 to the current year. The gage is a water-stage recorder and datum of the gage is 4,581.36 feet above sea level. (U.S. Forest Service bench mark).

USGS gage 12344000, Bitterroot River near Darby, MT: This gage can be used to monitor the flow in the Bitterroot River at Darby, MT.

USGS gage 12352500, Bitterroot River near Missoula, MT: This gage can be used to monitor the flow in the Bitterroot River at Missoula, MT.

WEATHER MONITORING

The dam operator monitors weather conditions, local weather forecasts, and the National Weather Service (NWS).

If sever flooding is anticipated, the NWS Missoula Office **(1-800-676-6975 or 406-329-4712)** should be requested to make "forecast points" of USGS gage located below the dam (USGS gage 12342500, West Fork Bitterroot River near Conner, MT). If this request is adopted, NWS will provide peak flow, storm duration, runoff duration (above base flow), and total volume flood forecast for this stream gauge as conditions warrant.

SNOTEL Sites: Current snow water equivalent and total precipitation can be monitored at two SNOTEL sites located above the reservoir -- Nez Perce Camp and Saddle Mountain. The information for these two sites can be accessed under the Bitterroot River Basin portion of the following USDA internet site:

ftp://ftp.wcc.nrcs.usda.gov/data/snow/update/mt.txt

Additional information about historical snowpack, precipitation, maps and graphs can be accessed at the following internet site:

http://www.mt.nrcs.usda.gov/swcs/snow/snow.html

INTERACTION WITH OTHER DAMS

There are no dams of any size above Painted Rocks reservoir. There are also no dams below Painted Rocks reservoir on the Bitterroot River. However, there are a number of irrigation diversion dams in the river and an irrigation siphon from Como Dam that crosses the river below the dam.

EMERGENCEY

If it appears that the Painted Rocks Dam is about to breach, or during emergency operations, the dam operator will initiate the **Painted Rocks Dam Emergency Action Plan.**

INSPECTION AND MONITORING

The SWPB inspects the dam annually. Appendix C includes an example of a SWPB inspection report form. In addition to annual inspections, SWPB or Missoula Regional Office personnel will inspect the dam and reservoir during and after heavy runoff, severe rainstorms and severe windstorms; during high storage periods; and after an earthquake. The embankment is not monitored by instrumentation.

STRUCTURAL FEATURES INSPECTION

Structural features include the outlet works, bridge, gatehouse, spillway, and dam embankment. The SWPB inspects these structures annually as part of its inspection program. Items to be checked or noted include, but are not limited to, the following:

1. Outlet Works
    a. Any differential settlement or movement resulting in cracking of the conduit
    b. Erosion of the seals or concrete by cavitation immediately downstream of the gates
    c. Major seepage of water into the conduit
    d. Deterioration of exposed concrete due to freeze/thaw cycles or sulfate reactions
    e. Operation of both gates
    f. Air vent for free, unobstructed operation
    g. All metal for corrosion
    h. Hoist machinery for proper lubrication
    i. Condition of hoist cables
2. Gate House
    a. Any damage or vandalism

3. Spillway
    a. Erosion of the spillway channel
    b. Blockage of the approach or exit channel
    c. Concrete condition
    d. Condition of the log boom
    e. Stilling basin
    f. Condition of the fence on the left stilling basin wall
4. Embankment
    a. Erosion
    b. Settlement, bulges, sink holes, cracking, misalignment
    c. Rip rap displacement
    d. Damage from burrowing animals
    e. Excessive vegetation, brush, trees
    f. Seepage
    g. Condition of the road across the dam
5. Bridge
    a. Deterioration of bridge surface
    b. Corrosion of steel
    c. Major structural cracking of wingwalls or abutment walls
    d. Deterioration of bearing pads
    e. Deterioration of concrete bridge support piers

RIPRAP INSPECTION

The riprap along the face of the dam should measure at least 30 (thirty) inches thick. Immediately after the occurrence of high water, the riprap should be inspected and additional riprap added if needed.

EMBANKMENT MONITORING POINTS

The are no monitoring measurement points on the dam embankment.

DRAINS

The are no drains in the dam embankment or spillway. There are several weep pipes in the spillway.

SEEPAGE

There are no reported or visible seepage areas on the dam embankment or below the dam embankment. There are a number of weep pipes located through the spillway floor that have had observable water flow. The flow amounts are small, estimated to be less than 1 gpm, and occur at high reservoir pool elevations.

MONITORING WELLS

There are no monitoring wells or other instrumentation on or below the dam embankment.

MAINTENANCE

The SWPB and the association are responsible for the routine maintenance of the project. In addition, the SWPB may identify items that need maintenance or repair during the annual inspection.

ROUTINE MAINTENANCE

To protect the dam and keep it in good working order, the dam operator (Missoula Regional Office Staff) during regular visits to the dam will watch for and identify any potential maintenance requirements. As soon as a need is identified, the dam operator will contact the association to schedule and perform the routine maintenance.

Items that may need occasional attention include, but are not limited to:

1. *Lubrication and cleaning of gate-operating mechanisms.*
2. *Debris or silt plugging the inlet or the outlet channel.* Accumulated debris that could affect the operation of these appurtenances should be removed at once.
3. *Erosion gullies on embankment.* Erosion gullies should be checked immediately. Gullies should be filled, compacted, and seeded. Particular attention should be paid to the groin/abutment contact areas.
4. *Rodent damage.* Rodents will be removed or destroyed, and any burrow holes should be filled immediately.
5. *Upstream slope riprap.* The upstream face riprap normally will be observed annually, but may occasionally need repairs because of high water or wave action.
6. *Vegetative cover on downstream slope.* Good vegetative cover must be maintained. Large brush and any trees should be removed.

7. *Noxious weeds.* Noxious weeds on and around the dam embankment and around the reservoir shall be sprayed at least on an annual basis.
8. *Cleaning spillway wall tops.* Spillway wall tops should be clear of any dirt, rocks, grass, brush, and any overhanging vegetation or trees.
9. Repair of the spillway joints and sealing of cracks in the spillway.
10. *Cable.* Check the cable (wire rope) for loss of cover, fraying and wear and replace when necessary.

ANNUAL MAINTENANCE

The SWPB conducts annual inspections of Painted Rocks Dam and reservoir. During these inspections, any items requiring annual maintenance will be identified and recorded. Items that may need annual maintenance are the outlet works, gates, cables, gatehouse, air vent structure, spillway, and the log boom. Other routine items needing immediate attention, such as the need to remove trees, brush, or tree roots/dead trees from the log boom will be noted.

After the inspection, the SWPB sends the Missoula Regional Office (MRO) and the association a Dam Safety Inspection Report and a Maintenance Report. The reports identify items that need maintenance and provides a schedule of when the maintenance tasks need to be completed. The SWPB and the association are responsible for performing the maintenance items within the times specified.

The SWPB and the association may perform the maintenance tasks. However, major repair's will likely to be handled by a contractor. The SWPB may assist in contracting for repairs and may supervise the repair work.

RECORD-KEEPING

The SWPB maintains records, including photographs, of all inspections and maintenance requirements. These records also include flow measurements and storage volumes. Anyone who wants to review these records may do so in the SWPB's office at the Department of Natural Resources and Conservation in Helena.

The dam operator will keep records of the reservoir elevation, seepage observation or measurements, and any unusual conditions. These records may be reviewed at the Missoula Regional Office.

26 2001

REFERENCES

U.S. Army Corps of Engineers. July 1980. Phase One Inspection Report, National Dam Safety Program, West Fork Bitterroot (Painted Rocks) Dam, Darby Montana, Ravalli County, MT-19. Prepared for the State of Montana (DNRC) by CH2M Hill, Bellevue, WA under the U.S. Army Corps of Engineers' National Dam Safety Program.

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Fischer, Gary, DNRC Engineer. April 20, 1993. PMF Calculations, letter.

Bureau of Reclamation. June 17 to 19, 1998. Report Of Travel Or Site Visit For Geologic Investigations. Prepared for the State of Montana (DNRC) by the BOR under the Technical Assistance to States (TATS) program.

APPENDICES

APPENDIX A

OPERATING PLAN

OPERATING PLAN FOR THE RELEASE OF WATER FROM PAINTED ROCKS RESERVOIR

MARCH 30, 1999

The purpose of this operating plan is to define how Painted Rocks Reservoir is to be operated, in order to meet Department (DNRC) obligations as provided in its Water Marketing Contract with the Painted Rocks Water Users' Association (PRWUA), and its Water Purchase Contracts with the Montana Department of Fish, Wildlife and Parks (DFWP). This plan for reservoir operation provides guidelines to accomplish water storage goals, satisfy water contract obligations, and meet winter operational needs at the reservoir. This plan also includes sections that detail reservoir statistics and operational facts, and it provides reference materials needed to implement the plan.

The Painted Rocks Reservoir Project is to be operated within the following guidelines to achieve the above stated DNRC goals:

REGULATE RESERVOIR ELEVATIONS

Goals:
* Maximize and maintain storage in spring
* Maintain adequate fall storage
* Protect the intake structure from freeze-thaw damage

Guidelines:

1. The DNRC Missoula Regional Office (MRO) will provide dam operator services for the operation of the dam gate and light maintenance at the dam site. The dam operator, will be responsible for maintaining the reservoir storage levels at an optimum elevation to maximize storage.

2. The dam operator will determine reservoir elevation and storage contents as needed, and make gate adjustments at the dam as needed, in order to maximize storage contents. The dam operator will record elevation and storage readings weekly from May 1 through September 30, and monthly from October 1 through April 30, every year.

3. The dam operator will make visits to the reservoir for gate adjustments or other purposes when special circumstances require. These visits generally will not occur more than once a week from May 1 through September 30.

4. By April 1 of each year, the DNRC shall evaluate reservoir storage, snowpack, streamflow, streamflow forecast, soil

moisture, and the extended weather forecast/outlook.

If the reservoir elevation is higher than average and indications are that a wet, high-runoff spring could exist, the DNRC will consider increasing the outflow to provide some capacity for flood control or postponing the use of the spillway so that it coincides with peak irrigation demand.

If the reservoir elevation is lower than average and conditions indicate that a dry, low-runoff spring could exist, the DNRC will inform the water users of the potential for water shortage, and to plan for dealing with decreased water availability for that year.

5. The dam operator will attempt to maintain the reservoir level at spillway crest elevation as long as spring runoff flows allow and there are no other prior right calls for those waters.

6 The dam operator will notify the Helena office when the Spring flood/runoff period has ended **and** when the water users have begun to call for release of their water to satisfy their contracts.

7. When the reservoir storage level reaches **15,000** acre-feet, the DNRC will inform the water users so they may determine how to allocate remaining water contract releases before September 30. The DNRC has established a benchmark at this elevation.

8. The reservoir storage contents may not be drawn down below **5,500 to 6,000** acre-feet after September 30 in any given year. All contracts will be considered satisfied when the reservoir storage reaches this level. The DNRC will establish a benchmark at this elevation.

9. The absolute minimum pool for the reservoir will be **1,907** acre-feet for protection of the intake structure during winter. The DNRC will establish a benchmark at this elevation.

10. In the year 2004 when the Water Marketing Agreement and Water Purchase Contracts expire and are then renegotiated, DNRC's goal is to transfer the day to day operation and maintenance responsibilities at the dam to the water users. At that time, DNRC will train the person chosen to assume the above described responsibilities.

REGULATE OUTFLOW:

Goals: *Satisfy Water Purchase Contracts
*Balance outflow with inflow
*Maximize storage
*Maintain appropriate winter outflow

Guidelines:

1. The recommended maximum sustainable outflow through the low level outlet works is **500** cfs. This rate can be exceeded up to a maximum of **3,000** cfs for short periods of time.

2. The minimum outflow during the winter low flow period, which is to be **not less than the inflow,** must be maintained at the dam outlet, with the exception of brief periods of gate closure for dam safety inspections, maintenance, dam safety, or emergency purposes.

3. The dam operator will be responsible for the operation of the gate in order to maintain a full reservoir pool through the spring runoff. Only inflow and contract water will be released thereafter.

   Inflow and outflow are to be monitored, and gate adjustments are to be made as necessary during the Spring and throughout the irrigation season, to balance inflow with outflow. This balance of flows is critical to insure that water contracts are satisfied, and that available flow for carry-over storage is captured and retained in the reservoir.

   If the reservoir is at spillway crest elevation after the runoff recedes, the gate will be operated to retain that pool until such time as contract water is "called " for by the users. Outflow should be adjusted to equal inflow rate.

   If spring runoff flow is available for storage after contract waters are called for, the gate shall be adjusted to maintain storage contents at spillway crest elevation until the water commissioner requests that the outflow be increased to satisfy prior existing water rights. Outflow will be adjusted to equal inflow rate plus the amount released for contracts.

   The dam operator will keep records of visits to the project and will document the inflow to the reservoir (stage, shift, and discharge for West Fork, Overwhich, Slate, and Blue Joint Creeks), the outflow at the USGS gage below the reservoir (stage, shift, and discharge), the corresponding elevation and storage contents for the reservoir, and the gate adjustments made to balance the flows and storage.

When making gate adjustments, the dam operator will remain on site long enough (approximately one hour) to observe that the hydrograph at the USGS gage stabilizes, insuring that the desired adjustment is achieved.

The dam operator will notify the Helena office when Spring runoff flows recede and when water contract deliveries begin.

Once it is necessary to operate the gate for the release of water to contract users, an accounting of the water released and the satisfaction of contracts is the responsibility of the dam operator. **All contracts will be considered satisfied once the reservoir is drafted down to 5,500 to 6,000 Acre-Feet** (see Water Purchase Contracts). The dam operator will not release any storage water to contract users after September 30 in any given year.

The dam operator will notify the Helena office SWPB Project Section supervisor when the dam operator is not available to operate the gate.

The dam operator will immediately notify the Helena office if there appears to be any problem with operation of the gate.

4. The dam gate is operated by a designated DNRC employee when the dam operator is unavailable to make needed gate adjustments, and when operation and maintenance work is needed at the project. The dam operator, and the Water Commissioner will be provided the list of those individuals.

5. All requests for water releases will be made and coordinated through the Water Commissioner to the dam operator or the DNRC.

6. DNRC will maintain the staff gages and rating tables for stage/discharge evaluations of the inflows of West Fork Bitterroot River, Overwhich, Slate, and Blue Joint Creeks at the bridge sites on those streams above the reservoir. The dam operator will use those gages, the USGS below the reservoir, and the reservoir slope-distance/elevation/storage table to facilitate gate operation and management of water releases.

See Manual for Operation and Maintenance for the above referenced tables.

7. In the year 2004 when the Water Marketing Agreement and Water Purchase Contracts expire and are then renegotiated, DNRC's goal is to transfer the day to day operation and maintenance responsibilities at the dam to the water users. At that time, DNRC will train the person chosen to assume the above described responsibilities.

EMERGENCY RESPONSE

Goals: *Provide maximum early warning in the event of a failure of the Painted Rocks Dam
*Minimize loss of life or property.

Guidelines: 1. The PRWUA and DNRC will follow the Emergency Action Plan for the Painted Rocks Reservoir.

MAINTENANCE

Goals: *Maintain the dam in good condition so that it will continue to fulfill its function providing a reliable source of irrigation water.
*Maintain the dam in good condition so as to minimize the risk to life or property downstream of the dam.

Guidelines: 1. The DNRC will operate and maintain the reservoir in accordance with the Painted Rocks Reservoir Manual for Operation and Maintenance until such time as these responsibilities are transferred to the PRWUA.

PROJECT STATISTICS

The Painted Rocks Dam was completed in 1939. Originally the water was used for the agricultural benefit of the Bitterroot Valley, but today it provides multipurpose benefits to in-stream flows, agriculture, lake recreation, and flood control. The dam is a 143-foot high, 800-foot long, curved-axis earth fill embankment. Its crest width varies from 20.5 to 35.5 feet. The dam impounds Painted Rocks Reservoir, which has a 45,100-acre-foot maximum capacity with a surface area of 655 acres at dam-crest elevation 4743.07. Surcharge storage of 12,700 acre-feet is available between the spillway crest and dam crest. The normal (total) capacity is 32,360 acre-feet at spillway crest elevation of 4725.5. Only 31,700 acre-feet is usable, the remaining 660 acre-feet is dead storage. It is the usable capacity of the reservoir that is available to satisfy water contracts sold from this water project.

The spillway, located in the right abutment, is an uncontrolled concrete chute with a low ogee crest control. The spillway crest width is 160 feet, tapering to 60 feet at the stilling basin. The capacity is 42,000 cfs when the reservoir level is at the dam crest elevation.

The estimated maximum discharge capacity of the outlet works is 3,000 cfs when the water surface is at dam crest. The outlet works is located in the right abutment of the dam. The intake structure consists of a 30 -foot-high concrete tower with trash racks on the tower top and on three sides. The concrete conduit is a 10-foot-diameter horseshoe section approximately 580 feet in length. The upstream 206 feet of concrete-lined tunnel section is founded on gravel and decomposed granite, and the remaining 374 feet go through granite. A wet-well gate tower is located about 340 feet downstream from the intake structure near the centerline of the dam. The controls for the two 5-foot by 8-foot tractor-type slide gates are in a gate house at the dam crest . A cable hoist mechanism powered by an electric motor operates the gates. In the event of a power failure, the gates can be operated manually.

PROJECT OPERATION

Presently, Painted Rocks Dam is operated and maintained by the Missoula Regional Office of the Montana Department of Natural Resources and Conservation (DNRC). The dam operator operates the gate at the direction of DNRC. DNRC receives requests for gate adjustments from the water commissioner, who coordinates the water orders from irrigators and the DFWP, when water is needed, usually no more than once every week. DNRC directs that gate adjustments be made at those times. When necessary due to water demand or a known imbalance between inflows and outflows, additional gate adjustments are made upon request of the water commissioner.

More frequent dam-gate operation is needed once spring runoff recedes and water delivery begins. This is necessary to assure that no storage water is being released that is not attributed to a “call” for it by a contract holder, and to assure that water is being retained for other contract releases and for carry-over storage. This management problem impacts the following operational concerns: the amount of storage water obligated under contracts; water losses; water measurement and accuracy; gate adjustments at the dam and the timing and accuracy thereof; operational characteristics and limitations of the gate; coordination of calls for releases of contract water; winter storage and release requirements and protection of the intake structure to the outlet works. These operational concerns will now be addressed more specifically.

WATER PURCHASE CONTRACTS, OBLIGATIONS AND WATER DELIVERY

Agricultural users (Irrigators) and the Department of Fish, Wildlife and Parks (DFWP) presently have contracted for 25,000 acre-feet of water from Painted Rocks Reservoir. There is only 31,700 acre-feet of usable storage in the reservoir at spillway crest elevation. The Water Purchase Contracts to Irrigators and DFWP are described as follows:

The DNRC entered into a Water Purchase Contract(WPC) with the Department of Fish, Wildlife and Parks(DFWP) on December 3, 1992, for 10,000 acre-feet of water, measured at the dam, between May 1 and September 30 annually. This water supplements in-stream flows for fish, wildlife, and recreation. This WPC expires on September 30, 2004, at the agreement of the parties. The DFWP also holds a March 5, 1958 Water Purchase Contract for 5,000 acre-feet of water for this same purpose. This 5,000 acre-feet is to be delivered at the confluence of the Bitterroot River and the Clarks Fork River, and is without expiration date.

The DNRC entered into a Water Marketing Contract(WMC) with the Painted Rocks Water Users' Association(PRWUA) in 1993, marketing 10,000 acre-feet of water to local users (Irrigators) through DNRC approval of individual Water Purchase Contracts(WPC). These contracts are delivered at the dam. This 10,000 acre-feet is to be used for irrigation, stock watering and domestic uses. These contracts, WMC and WPC expire on September 30, 2004, at the agreement of the parties.

The goal of this plan is to assure that DNRC satisfies its contractual obligations, and maintains adequate outflows and reservoir storage through the winter. This goal will be accomplished by filling the reservoir in the spring, maintaining a full storage level as long as stream flows are available, and then releasing only the water that is called for by the water purchase contract users in conjunction with the unappropriable inflows during the water use season. The water-use season and time period for delivery of contract water is stated in the water purchase contracts as May 1 thru September 30. The 1958 DFWP contract is the only contract that does not define a specific time period for water delivery.

To understand how water is released for the project water users, one has to be cognizant of the contractual obligations and conditions that exist between the DNRC and the project users. It is important to know that the water released to project water users is measured at the dam (USGS gage below dam), and this is specifically stated in the WMC and WPC agreements with the Water Users' Association and the individual water users. Section 2 in the WMC states clearly that the Department is obligated only to impound the water and make the water available to the Association at the reservoir. The Department shall be under no obligation to distribute water to those entitled to water under water purchase contracts, as stated in Section 2 of the WMC and Section 9 of the WPC. The

WMC does not guarantee water supply. The Department shall use all reasonable means to guard against water shortage, but in no event shall the Department or any of its officers, agents or employees be liable for any damage, direct or indirect, arising from water shortage, flood, failure of the project, or otherwise. Importantly, it is stated in section 3 of the WPC that the Department and the Association(PRWUA) do not guarantee that the quantity of water contracted for by the water purchaser will be made available. If in any year there is insufficient water from the project to fill outstanding water contracts, the water purchaser shall be entitled to a portion of the total water available equal to the fraction that the quantity of water in his/her contract bears to the total quantity of water under outstanding water purchase contracts. The release to the water purchaser of this proportionate share of available water shall be complete performance by the Department and Association for that year. This is an extremely critical consideration because it underscores the importance of starting the irrigation season with a full reservoir and for full accounting for all water released to satisfy the calls for contract waters. Section 3 in the WMC states the Association (PRWUA) shall cause the water to be put to beneficial use with diligence for irrigation, stock watering, and domestic uses in accordance with the law and Department regulations and policies. Section 11 in the WMC addresses the Departments right to make and amend reasonable rules and regulations with respect to the operation and administration of the project. The WMC and individual WPC expire on September 30, 2004, and will be renegotiated on or before that time; there are current discussions to renegotiate the WMC now.

Currently, the dam operator operates the gate at the direction of DNRC. DNRC receives requests for gate adjustments from the water commissioner who coordinates the water orders from irrigators and the DFWP, usually no more than once every week. DNRC effects gate adjustments at those times, or earlier if necessary. Gate adjustments are made by the dam operator or DNRC personnel, if necessary.

Historically, during the irrigation season, it has been the operational goal that the outflows from the reservoir be adjusted such that they equal only the combined inflows to the reservoir plus the release of storage water attributed to calls for contract water. This satisfied the calls for contracted water, maintained the storage for additional water sales and remaining contract obligations, and protected prior existing water rights below the project.

Prior to 1989, because of limited water sales, achieving the above operational goal was not difficult because significant reservoir storage helped compensate for any errors in gate adjustments. Since 1989, however, it has been demonstrated that gate adjustments balancing inflow and outflow are critical if water contract obligations are to be met and protection of the intake structure to the outlet works is to be insured.

More frequent gate operation is the management goal that needs to be achieved now in order to balance inflows, outflows and storage. It is critical to insure that carry-over storage water is stored and retained when water is available during the runoff, and no water from storage is released that is not attributed to a call for water under a water purchase contract. Recent problems with reservoir operation have been the result of not paying close enough attention to the above referenced balances, thereby creating contract delivery and fall storage shortages. This operating plan will provide guidelines to correct this problem.

WATER LOSS

Since conveyance losses are sufferred by the contract holders, water losses are an important issue. Water contracts specify that they are delivered "at the dam". Contract users cannot take their full contract amount at their headgate, because they would deplete the Reservoir storage and severely affect the fair distribution of the storage water to other authorized users. The amount of water lost during conveyence is not easily determined, so users must understand that the amount of water contracted for at the dam will be less than the amount of water received at their headgate. It is known from measurements that approximately 20% of water released from the reservoir is lost before it reaches Darby, Montana. This can be observed by comparing changes to outflows after gate adjustments at the reservoir (by reading at the USGS gage below the reservoir), to the change in flow at the USGS gage on the Bitterroot River near Darby. It takes approximately 9 hours for changes in flow, occuring as a result of gate adjustments, to appear at the USGS gage at Darby.

In a test release in April, 1984, about 18% of the supplemental water released was lost before reaching Darby. Approximately 63% of this water was lost before reaching Bell Crossing. The loss of water due to natural causes could not be separated from loss due to diversion. This test result appeared in a Draft Water Management Plan For The Proposed Purchase Of Supplemental Water From Painted Rocks Reservoir, Bitterroot River, Montana. This draft plan was prepared by Mark Lere for the DFWP and is dated June 30, 1984.

It is extremely important to recognize that water losses can be significant. Before 1989, there was less water sold under contract and satisfaction of existing contracts was not a concern. It should be obvious that current contract obligations may exceed the ability to deliver the amount established in the 1958 contract. More importantly, the right of the DNRC to market water is limited to only one filling of the reservoir, because the project cannot control excess flood flows, and the DNRC never addressed the marketing of such flows.

WATER MEASUREMENT

Prior to 1997, operation of the reservoir gate was based on measurements of reservoir storage using slope-distance/elevation/storage tables and on visual estimates of inflow correlated with outflows as shown by the USGS gage below the reservoir. This method appeared to be adequate until significantly more water was sold under contracts after1989. The success of this method was due to the knowledge and experience of the dam operators and water commissioner. However, now that all the water in the project is basically sold, it has become apparent that more accurate inflow information is necessary to balance inflows with outflows. Although historically there have been staff gages on bridges on the major tributaries above the reservoir, it is not known to what extent they were used, or if used at all. Since the fall of 1997, the DNRC has taken water measurements at various water stages with a Marsh-McBirney Flowmate 2000 flowmeter and has developed stage/discharge tables for the West Fork Bitterroot River, Overwhich Creek, Slate Creek, and Bluejoint Creek to provide accurate inflow readings for gate adjustments. The water commissioner has used these tables and has stated that they have been very beneficial. It is most important that the available gaging instruments and information be used frequently enough to determine any imbalance between outflows and inflows during periods of water release to water users, so that immediate gate adjustments can be made. The major goal and reason for this management plan is to insure, to the best of our ability, that no water is released from the reservoir that is not attributed to calls for contract water from storage during the irrigation season . As stated earlier in this document, excess (unbalanced) outflow depletes storage water that will not be available to satisfy a call for contract water requested later in the season.

GATE ADJUSTMENT AT THE DAM

Timely and accurate gate adjustments made at the dam are the critical factor in this plan. Until now the gate adjustments have been made generally once a month during the non-irrigation season, and bi-monthly during the irrigation season, with intermediate adjustments made as the need arose. Since 1989 it has been found that this is not often enough. If the balance between inflow and outflow is not correct after a gate adjustment is made, then reservoir storage water is lost before the next scheduled adjustment is made. To eliminate this problem, there needs to be better assessment of the reservoir volume and flow status before and after gate adjustments are made. DNRC has recently developed gaging information to more accurately determine inflows, which were estimated previously. It is DNRC's intent to continue to measure inflows and to maintain rating tables for the staff gages on the four major tributaries above the reservoir. Existing instrumentation for reservoir storage and outflow information is adequate. Outflows are adjusted using the operating gate, which is raised and lowered with a cable hoist mechanism run by an electric motor. There is also an “emergency” gate, located adjacent to the operating gate. In the event of a power failure the gates can be operated manually.

To effect a satisfactory gate adjustment requires the following: First, the inflow needs to be determined by reading the staff gages above the reservoir and applying the shifts to the ratings tables for each of the four tributaries gaged, then these flows must be totaled. Before the adjustment is made, the existing outflow needs to be determined by reading the USGS stream gage below the dam and applying the proper shift to the rating table, which is established and maintained by the USGS and posted in the gage house. At the same time, the final stage height at this gaging station needs to be determined in order to accomplish the necessary adjustment. How much to open or close the gate is a trial and error exercise, but the operator usually watches how far the drum (spool) turns as it raises or lowers the cable operating the gate. It is common knowledge among those with experience operating this gate, that if one gets within 10 or 15 cfs of his desired adjustment, that goal has been accomplished. This is understandable when one considers that a one-inch elevation change in the gate opening results in a change in the cross-sectional area of the gate opening of approximately 0.42 square feet. With the reservoir head determining the discharge through this opening, an adjustment for only 15 cfs may require that the drum turn only 8 or 10 teeth of its gears from its pre-adjustment position. Most importantly, it takes approximately one hour for the flows through the gate and outlet to stabilize such that the hydrograph at the USGS gage below the reservoir reads stable(unchanging) flow. Therefore, the operator needs to wait one hour after he operates the gate to determine the status of his change, then readjust if necessary, wait another hour, and so on, until he accomplishes his goal. Another complicating feature in these adjustments is that sometimes the gate binds in its slide tracks. This is normally not a problem, but it can be troublesome in the fall or winter time, if the gate cannot be closed enough to prevent loss of storage. Usually the raising and lowering of the gate will correct the situation , and if not, it is remedied by closing the emergency gate to take pressure off of the operating gate, thus allowing the operating gate to realign and move freely again. Sometimes, the operating gate will not close as far as desired.

For the reasons and factors described above, the gate adjustments made in the fall are probably the most critical, because the reservoir is at its carry-over storage level for the winter and inflows are at levels which will likely drop as the winter progresses. Historically, the operational goal in the fall is to set the operating gate so inflow equals outflow, and once it is set, it will remain there till spring. This is done so that the flows remain constant for fisheries concerns. If the gate at the dam cannot be closed enough to insure that outflows from the reservoir don't exceed the inflows, then storage is lost through the winter months, and there is a risk that the reservoir can empty enough to expose and freeze the intake structure for the outlet works. This could cause severe and costly damage to the project. To insure this doesn't occur, the DNRC is developing this plan to attempt to optimize the reservoir storage on October 1 and make an acceptable final gate adjustment at that time to retain adequate reservoir contents until inflows increase storage contents in the spring.

WINTER OPERATION

The year end goal of project management is to have enough water in the reservoir to provide winter protection for the intake structure, while at the same time allowing adequate outflows for in-stream flow needs. Since water purchase contracts have been sold totaling 25,000 Acre-Feet, it has been determined that a minimum of **5,500 to 6,000** acre-feet of usable storage water is needed in the reservoir on October 1 in any given year. This minimum volume is needed because winter inflows oftentimes decrease after the last gate adjustment of the year, and when outflows exceed inflows, the reservoir loses storage. Knowing that losses will occur, the goal is to keep a sustainable quantity until inflows increase to replace losses and to insure the losses will not result in the exposure of the intake structure. By way of example, on September 30, 1997 there was 6,620 Acre-Feet of water in the reservoir, and the outflows were approximately equal to the inflows at 94 cfs. As the inflows dropped below winter outflows, there were difficulties in closing the gate below 80 cfs. Losses from storage were such that on March 12, 1998 the reservoir storage was only 1,570 Acre-Feet. This water level was only 5.4 feet above the grate on the intake structure. Fortunately, spring flows increased shortly thereafter and the reservoir began filling. The point is that unforeseen winter operations and/or hydrologic conditions require special preparations or planning, if serious problems are to be avoided.

The operational goal for winter flow releases from the project is that inflows are to equal outflows. The operational problem in this regard is that the gate operation is difficult at this time of year. At times the operating gate will not close enough to achieve the lower flow targets, due to misalignment, and then the gate sticks. At those times, different methods are used to achieve the right setting, but raising the gate is usually not attempted. Consequently, DNRC's goal is to make a final gate adjustment for winter before the end of October. The DNRC will insist upon achieving this goal, and will not make allowances unless special conditions arise that would dictate some other plan of action. Such actions, if necessary, would require notification and involvement of the PRWUA, DFWP, and all other contract water users.

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APPENDIX B

RATING CURVES AND TABLES

TABLE 1. SLOPE-ELEVATION-STORAGE TABLE

PAINTED ROCKS RESERVOIR - BOAT RAMP

Pins installed and elevations established using a level in 1997.
The 0+00 pin located at the upper left (upstream) corner of the concrete boat ramp slab.
Measurements taken along the left (upstream) side of the boat ramp slab.
Storage volumes from original 1938 hand surveys.

DISTANCE feet	ELEVATION feet	STORAGE acre-feet	NOTES
0	4,730.21	34,975	Top ring #1
0	4,729.91	34,767	Base ring #1
1	4,729.88	34,746	
2	4,729.85	34,725	
3	4,729.82	34,704	
4	4,729.79	34,683	
5	4,729.76	34,662	
6	4,729.73	34,642	
7	4,729.70	34,621	
8	4,729.67	34,600	
9	4,729.64	34,579	
9.3	4,729.63	34,572	Saw cut
10	4,729.60	34,551	
11	4,729.55	34,517	
12	4,729.51	34,489	
13	4,729.46	34,454	
14	4,729.42	34,426	
15	4,729.37	34,392	
16	4,729.33	34,364	
17	4,729.28	34,329	
18	4,729.23	34,295	
19	4,729.19	34,267	
19.2	4,729.18	34,260	Joint
20	4,729.13	34,225	
21	4,729.07	34,184	
22	4,729.01	34,142	
23	4,728.95	34,100	
24	4,728.89	34,059	
25	4,728.83	34,017	
26	4,728.77	33,975	
27	4,728.71	33,934	
28	4,728.65	33,892	
29	4,728.59	33,850	
30	4,728.53	33,809	
31	4,728.47	33,767	
31.1	4,728.46	33,760	Saw cut
32	4,728.39	33,712	
33	4,728.32	33,663	
34	4,728.24	33,608	
35	4,728.17	33,559	
36	4,728.10	33,510	
37	4,728.02	33,455	
38	4,727.95	33,406	
39	4,727.87	33,351	
40	4,727.80	33,302	
41	4,727.73	33,254	
42	4,727.65	33,198	
43	4,727.58	33,150	
43.1	4,727.57	33,143	Joint
44	4,727.52	33,108	
44.35	4,727.76	33,274	Top ring #2
44.35	4,727.50	33,094	Base ring #2
45	4,727.44	33,052	
46	4,727.35	32,990	
47	4,727.26	32,927	
48	4,727.17	32,865	
49	4,727.07	32,796	
50	4,726.98	32,733	
51	4,726.89	32,671	
52	4,726.80	32,608	
53	4,726.71	32,564	
54	4,726.61	32,476	
55	4,726.52	32,414	
55.9	4,726.44	32,358	Saw cut
56	4,726.43	32,351	
57	4,726.34	32,289	
58	4,726.25	32,226	
59	4,726.16	32,164	
60	4,726.07	32,102	
61	4,725.98	32,039	
62	4,725.89	31,977	
63	4,725.80	31,914	
64	4,725.71	31,852	
65	4,725.62	31,789	
66	4,725.53	31,727	
66.3	4,725.50	31,706	Spillway crest
67	4,725.44	31,670	
68	4,725.35	31,615	
68.8	4,725.28	31,573	Joint
69	4,725.26	31,561	
70	4,725.16	31,500	
71	4,725.07	31,446	
72	4,724.97	31,385	
73	4,724.87	31,324	

TABLE 1. SLOPE-ELEVATION-STORAGE TABLE (continued)

PAINTED ROCKS RESERVOIR - BOAT RAMP

DISTANCE feet	ELEVATION feet	STORAGE acre-feet	NOTES	DISTANCE feet	ELEVATION feet	STORAGE acre-feet	NOTES
74	4,724.78	31,270		118	4,720.15	28,463	
75	4,724.68	31,209		118.4	4,720.11	28,439	Joint
76	4,724.58	31,148		119	4,720.04	28,396	
77	4,724.49	31,094		120	4,719.93	28,330	
78	4,724.39	31,033		121	4,719.82	28,263	
79	4,724.29	30,973		122	4,719.71	28,196	
80	4,724.20	30,918		123	4,719.60	28,130	
80.7	4,724.13	30,876	Saw cut	124	4,719.49	28,063	
81	4,724.10	30,858		125	4,719.38	27,996	
82	4,724.00	30,797		126	4,719.27	27,930	
83	4,723.90	30,736		127	4,719.16	27,863	
84	4,723.80	30,676		128	4,719.05	27,796	
85	4,723.70	30,615		129	4,718.94	27,730	
86	4,723.60	30,555		130	4,718.83	27,663	
87	4,723.49	30,488		130.3	4,718.80	27,645	Joint
88	4,723.39	30,427		131	4,718.72	27,596	
89	4,723.29	30,367		132	4,718.60	27,524	
90	4,723.19	30,306		133	4,718.49	27,457	
91	4,723.09	30,245		134	4,718.37	27,384	
92	4,722.99	30,184		135	4,718.26	27,317	
92.7	4,722.92	30,142	Joint	136	4,718.14	27,244	
93	4,722.89	30,124		137	4,718.03	27,178	
94	4,722.78	30,057		138	4,717.91	27,105	
95	4,722.67	29,990		139	4,717.80	27,038	
96	4,722.56	29,923		140	4,717.68	26,965	
97	4,722.45	29,857		141	4,717.57	26,898	
98	4,722.34	29,790		142	4,717.45	26,826	
99	4,722.23	29,723		142.3	4,717.42	26,808	Joint
100	4,722.12	29,657		143	4,717.34	26,759	
101	4,722.01	29,590		144	4,717.22	26,686	
102	4,721.90	29,523		145	4,717.10	26,614	
103	4,721.79	29,457		146	4,716.99	26,547	
104	4,721.68	29,390		147	4,716.87	26,474	
105	4,721.57	29,323		148	4,716.75	26,402	
105.6	4,721.50	29,281	Saw cut	149	4,716.64	26,335	
106	4,721.46	29,257		150	4,716.52	26,262	
107	4,721.35	29,190		151	4,716.40	26,189	
108	4,721.24	29,123		152	4,716.29	26,123	
109	4,721.13	29,057		153	4,716.17	26,050	
110	4,721.02	28,990		154	4,716.05	25,977	
111	4,720.91	28,923		154.7	4,715.97	25,929	Saw cut
112	4,720.81	28,857		155	4,715.94	25,911	
113	4,720.70	28,796		156	4,715.82	25,838	
114	4,720.59	28,730		157	4,715.71	25,771	
115	4,720.48	28,663		158	4,715.60	25,705	
116	4,720.37	28,596		159	4,715.49	25,639	
117	4,720.26	28,530		160	4,715.38	25,581	

TABLE 1. SLOPE-ELEVATION-STORAGE TABLE (continued)

PAINTED ROCKS RESERVOIR - BOAT RAMP

DISTANCE feet	ELEVATION feet	STORAGE acre-feet	NOTES
161	4,715.26	25,518	
162	4,715.15	25,461	
163	4,715.04	25,403	
164	4,714.93	25,345	
165	4,714.82	25,288	
166	4,714.70	25,225	
167	4,714.59	25,167	
167.2	4,714.57	25,157	Joint
168	4,714.48	25,110	
169	4,714.36	25,047	
170	4,714.24	24,984	
171	4,714.13	24,926	
172	4,714.01	24,863	
173	4,713.90	24,806	
174	4,713.78	24,743	
175	4,713.66	24,680	
176	4,713.55	24,622	
177	4,713.43	24,559	
178	4,713.32	24,502	
179	4,713.20	24,439	Saw cut
180	4,713.09	24,381	
181	4,712.97	24,318	
182	4,712.86	24,260	
183	4,712.74	24,197	
184	4,712.63	24,139	
185	4,712.52	24,082	
186	4,712.40	24,019	
187	4,712.29	23,961	
188	4,712.17	23,898	
189	4,712.06	23,840	
190	4,711.94	23,778	
191	4,711.83	23,720	Joint
192	4,711.72	23,662	
193	4,711.61	23,605	
194	4,711.51	23,552	
195	4,711.40	23,495	
196	4,711.29	23,437	
197	4,711.18	23,379	
198	4,711.07	23,322	
199	4,710.96	23,264	
200	4,710.86	23,212	
201	4,710.75	23,154	
202	4,710.64	23,096	
203	4,710.53	23,039	
203.2	4,710.51	23,028	Saw cut
204	4,710.42	22,981	
205	4,710.31	22,923	
206	4,710.19	22,861	
207	4,710.08	22,803	
208	4,709.97	22,745	
209	4,709.85	22,682	
210	4,709.74	22,625	
211	4,709.63	22,567	
212	4,709.51	22,504	
213	4,709.40	22,447	
214	4,709.29	22,389	
215	4,709.17	22,326	
215.2	4,709.15	22,316	Joint
216	4,709.06	22,268	
217	4,708.94	22,206	
218	4,708.82	22,143	
219	4,708.71	22,085	
220	4,708.59	22,022	
221	4,708.47	21,959	
222	4,708.36	21,902	
223	4,708.24	21,839	
224	4,708.12	21,776	
225	4,708.01	21,718	
226	4,707.89	21,655	
227	4,707.77	21,592	
227.1	4,707.76	21,587	Saw cut
228	4,707.66	21,534	
229	4,707.56	21,482	
230	4,707.45	21,424	
231	4,707.34	21,366	
232	4,707.23	21,309	
233	4,707.13	21,256	
234	4,707.02	21,198	
235	4,706.91	21,141	
236	4,706.80	21,083	
237	4,706.70	21,031	
238	4,706.59	20,973	
239	4,706.48	20,916	
239.1	4,706.47	20,910	Joint
240	4,706.37	20,858	
241	4,706.25	20,795	
242	4,706.14	20,737	
243	4,706.02	20,674	
244	4,705.91	20,617	
245	4,705.79	20,554	
246	4,705.68	20,496	
247	4,705.57	20,439	
248	4,705.45	20,379	
249	4,705.34	20,330	

TABLE 1. SLOPE-ELEVATION-STORAGE TABLE (continued)

PAINTED ROCKS RESERVOIR - BOAT RAMP

DISTANCE feet	ELEVATION feet	STORAGE acre-feet	NOTES
250	4,705.22	20,276	
250.2	4,705.20	20,267	Saw cut
251	4,705.11	20,226	
252	4,705.01	20,181	
253	4,704.90	20,131	
254	4,704.79	20,082	
255	4,704.68	20,032	
256	4,704.57	19,983	
257	4,704.47	19,938	
258	4,704.36	19,888	
259	4,704.25	19,839	
260	4,704.14	19,789	
261	4,704.03	19,740	
261.6	4,703.97	19,713	Joint
262	4,703.93	19,695	
263	4,703.82	19,645	
264	4,703.71	19,596	
265	4,703.60	19,546	
266	4,703.49	19,496	
267	4,703.38	19,447	
268	4,703.27	19,397	
269	4,703.16	19,348	
270	4,703.06	19,303	
271	4,702.95	19,253	
272	4,702.84	19,203	
273	4,702.73	19,154	
274	4,702.62	19,104	Saw cut
275	4,702.51	19,055	
276	4,702.41	19,009	
277	4,702.30	18,980	
278	4,702.19	18,910	
279	4,702.08	18,861	
280	4,701.98	18,815	
281	4,701.87	18,766	
282	4,701.76	18,716	
283	4,701.65	18,667	
284	4,701.55	18,622	
285	4,701.44	18,572	
286	4,701.33	18,523	
286.4	4,701.29	18,505	Joint
287	4,701.22	18,473	
288	4,701.11	18,424	
289	4,701.00	18,374	
290	4,700.89	18,325	
291	4,700.77	18,271	
292	4,700.66	18,221	
293	4,700.55	18,172	
294	4,700.44	18,117	
295	4,700.32	18,068	
296	4,700.21	18,018	
297	4,700.10	17,969	
298	4,699.99	17,914	
298.4	4,699.94	17,896	Saw cut
299	4,699.88	17,869	
300	4,699.78	17,824	
301	4,699.68	17,779	
302	4,699.58	17,734	
303	4,699.48	17,689	
304	4,699.38	17,644	
305	4,699.27	17,594	
306	4,699.17	17,549	
307	4,699.07	17,504	
308	4,698.97	17,459	
309	4,698.87	17,414	
310	4,698.77	17,369	
310.6	4,698.71	17,342	Joint
311	4,698.67	17,324	
312	4,698.58	17,283	
313	4,698.49	17,242	
314	4,698.40	17,202	
315	4,698.30	17,157	
316	4,698.21	17,116	
317	4,698.12	17,076	
318	4,698.03	17,035	
319	4,697.93	16,990	
320	4,697.84	16,949	
321	4,697.75	16,909	
322	4,697.65	16,864	
322.7	4,697.59	16,837	Saw cut
323	4,697.57	16,828	
324	4,697.48	16,787	
325	4,697.40	16,751	
326	4,697.32	16,715	
327	4,697.24	16,679	
328	4,697.16	16,643	
329	4,697.08	16,607	
330	4,697.00	16,571	
331	4,696.92	16,535	
332	4,696.84	16,499	
333	4,696.76	16,463	
333.8	4,696.97	16,558	Top last ring
334	4,696.68	16,427	
334.45	4,696.64	16,409	End conc.

TABLE 2. SLOPE-ELEVATION-STORAGE TABLE

PAINTED ROCKS RESERVOIR - BELOW BOAT RAMP

Pins installed and elevations established using a level in 1997.
The 0+00 pin located at the bottom left (upstream) corner of the concrete boat ramp slab.
Measurements begin at the ring at the bottom of the concrete boatramp.
Storage volumes from original 1938 hand surveys.

DISTANCE feet	ELEVATION feet	STORAGE acre-feet	NOTES
0	4,696.97	16,558	Top last ring
0	4,696.64	16,409	End conc.
1	4,696.52	16,355	
2	4,696.39	16,296	
3	4,696.27	16,242	
4	4,696.14	16,184	
5	4,696.02	16,130	
6	4,695.90	16,075	
7	4,695.77	16,017	
8	4,695.65	15,963	
9	4,695.52	15,904	
10	4,695.40	15,857	
11	4,695.28	15,812	
12	4,695.15	15,762	
13	4,695.03	15,717	
14	4,694.90	15,668	
15	4,694.78	15,622	
16	4,694.66	15,577	
17	4,694.53	15,527	
18	4,694.41	15,482	
19	4,694.28	15,433	
20	4,694.16	15,387	
21	4,694.04	15,342	
22	4,693.91	15,292	
23	4,693.79	15,247	
24	4,693.66	15,198	
25	4,693.54	15,152	
26	4,693.46	15,122	
27	4,693.38	15,091	
28	4,693.30	15,061	
29	4,693.22	15,031	
30	4,693.14	15,000	
31	4,693.06	14,970	
32	4,692.97	14,936	
33	4,692.89	14,905	
34	4,692.81	14,875	
35	4,692.73	14,844	
36	4,692.65	14,814	
37	4,692.57	14,784	
38	4,692.49	14,753	
39	4,692.41	14,719	
40	4,692.33	14,693	
41	4,692.25	14,662	
42	4,692.17	14,632	
43	4,692.09	14,602	
44	4,692.00	14,568	
45	4,691.92	14,537	
46	4,691.84	14,507	
47	4,691.76	14,477	
48	4,691.68	14,446	
49	4,691.60	14,416	
50	4,691.67	14,442	Top pin #1
50	4,691.52	14,386	Top block #1
51	4,691.46	14,363	
52	4,691.40	14,340	
53	4,691.34	14,317	
54	4,691.28	14,295	
55	4,691.23	14,276	
56	4,691.17	14,253	
57	4,691.11	14,230	
58	4,691.05	14,207	
59	4,690.99	14,185	
60	4,690.93	14,162	
61	4,690.82	14,120	
62	4,690.71	14,079	
63	4,690.60	14,037	
64	4,690.49	13,995	
65	4,690.39	13,954	
66	4,690.28	13,916	
67	4,690.17	13,874	
68	4,690.06	13,832	
69	4,689.95	13,791	
70	4,689.84	13,749	
71	4,689.71	13,700	
72	4,689.57	13,647	
73	4,689.44	13,597	
74	4,689.30	13,544	
75	4,689.17	13,491	
76	4,689.03	13,442	
77	4,688.90	13,389	
78	4,688.76	13,340	
79	4,688.63	13,286	

TABLE 2. SLOPE-ELEVATION-STORAGE TABLE (continued)

PAINTED ROCKS RESERVOIR - BELOW BOAT RAMP

DISTANCE feet	ELEVATION feet	STORAGE acre-feet	NOTES	DISTANCE feet	ELEVATION feet	STORAGE acre-feet	NOTES
80	4,688.49	13,237		125	4,680.15	10,368	
81	4,688.30	13,165		126	4,680.02	10,326	
82	4,688.11	13,093		127	4,679.90	10,287	
83	4,687.91	13,017		128	4,679.77	10,245	
84	4,687.72	12,945		129	4,679.65	10,206	
85	4,687.53	12,872		130	4,679.52	10,164	
86	4,687.25	12,766		131	4,679.39	10,121	
87	4,686.97	12,660		132	4,679.26	10,079	
88	4,686.70	12,558		133	4,679.14	10,040	
89	4,686.42	12,452		134	4,679.01	9,998	
90	4,686.14	12,346		135	4,678.88	9,956	
91	4,685.80	12,217		136	4,678.75	9,914	
92	4,685.45	12,087		137	4,678.62	9,872	
93	4,685.11	11,977		138	4,678.50	9,833	
94	4,684.76	11,863		139	4,678.37	9,791	
95	4,684.42	11,753		140	4,678.24	9,749	
96	4,684.19	11,678		141	4,678.13	9,713	
97	4,683.96	11,604		142	4,678.02	9,677	
98	4,683.72	11,526		143	4,677.91	9,642	
99	4,683.49	11,451		144	4,677.80	9,606	
100	4,683.38	11,415	Top pin #2	145	4,677.69	9,571	
100	4,683.26	11,376	Top block #2	146	4,677.58	9,535	
101	4,682.97	11,282		147	4,677.47	9,499	
102	4,682.68	11,188		148	4,677.36	9,464	
103	4,682.39	11,094		149	4,677.25	9,428	
104	4,682.09	10,997		150	4,677.27	9,434	Top pin #3
105	4,681.80	10,903		150	4,677.14	9,392	Top block #3
106	4,681.51	10,809		151	4,676.99	9,343	
107	4,681.41	10,777		152	4,676.84	9,295	
108	4,681.30	10,741		153	4,676.68	9,243	
109	4,681.20	10,709		154	4,676.53	9,194	
110	4,681.09	10,673		155	4,676.38	9,145	
111	4,681.06	10,663		156	4,676.23	9,097	
112	4,681.03	10,654		157	4,676.08	9,048	
113	4,681.00	10,644		158	4,675.92	8,996	
114	4,680.97	10,634		159	4,675.77	8,947	
115	4,680.94	10,625		160	4,675.62	8,899	
115	4,680.94	10,612		161	4,675.58	8,886	
117	4,680.87	10,602		162	4,675.54	8,873	
118	4,680.84	10,592		163	4,675.50	8,860	
119	4,680.81	10,582		164	4,675.46	8,849	
120	4,680.78	10,573		165	4,675.42	8,838	
121	4,680.65	10,531		166	4,675.38	8,827	
122	4,680.53	10,492		167	4,675.34	8,817	
123	4,680.40	10,450		168	4,675.30	8,806	
124	4,680.28	10,411		169	4,675.26	8,795	

TABLE 2. SLOPE-ELEVATION-STORAGE TABLE (continued)

PAINTED ROCKS RESERVOIR - BELOW BOAT RAMP

DISTANCE feet	ELEVATION feet	STORAGE acre-feet	NOTES
170	4,675.22	8,784	
171	4,675.11	8,754	
172	4,674.99	8,722	
173	4,674.88	8,692	
174	4,674.77	8,662	
175	4,674.66	8,630	
176	4,674.54	8,600	
177	4,674.43	8,570	
178	4,674.32	8,540	
179	4,674.20	8,508	
180	4,674.09	8,478	
181	4,673.94	8,437	
182	4,673.79	8,397	
183	4,673.64	8,356	
184	4,673.49	8,315	
185	4,673.35	8,275	
186	4,673.20	8,237	
187	4,673.05	8,196	
188	4,672.90	8,156	
189	4,672.75	8,115	
190	4,672.60	8,075	
191	4,672.41	8,024	
192	4,672.23	7,975	
193	4,672.04	7,923	
194	4,671.86	7,875	
195	4,671.67	7,823	
196	4,671.48	7,772	
197	4,671.30	7,723	
198	4,671.11	7,671	
199	4,670.93	7,623	
200	4,670.81	7,590	Top pin #4
200	4,670.72	7,566	Top block #4
201	4,670.53	7,514	
202	4,670.34	7,463	
203	4,670.14	7,408	
204	4,669.95	7,357	
205	4,669.76	7,305	
205	4,669.57	7,254	
207	4,669.38	7,202	
208	4,669.18	7,148	
209	4,668.99	7,097	
210	4,668.80	7,045	
211	4,668.68	7,013	
212	4,668.57	6,983	
213	4,668.45	6,950	
214	4,668.34	6,921	
215	4,668.22	6,888	
216	4,668.10	6,856	
217	4,667.99	6,826	
218	4,667.87	6,794	
219	4,667.76	6,764	
220	4,667.64	6,732	
221	4,667.60	6,721	
222	4,667.55	6,708	
223	4,667.51	6,694	
224	4,667.47	6,686	
225	4,667.43	6,675	
226	4,667.38	6,661	
227	4,667.34	6,651	
228	4,667.30	6,640	
229	4,667.25	6,626	
230	4,667.21	6,615	
231	4,667.21	6,615	
232	4,667.20	6,613	
233	4,667.20	6,613	
234	4,667.19	6,610	
235	4,667.19	6,610	
236	4,667.19	6,610	
237	4,667.18	6,607	
238	4,667.18	6,607	
239	4,667.17	6,605	
240	4,667.17	6,605	
241	4,667.14	6,596	
242	4,667.12	6,591	
243	4,667.09	6,583	
244	4,667.07	6,577	
245	4,667.04	6,569	
246	4,667.01	6,559	
247	4,666.99	6,556	
248	4,666.96	6,548	
249	4,666.94	6,542	
250	4,666.91	6,534	
251	4,666.88	6,526	
252	4,666.85	6,518	
253	4,666.82	6,510	
254	4,666.79	6,502	
255	4,666.76	6,493	
256	4,666.73	6,485	
257	4,666.70	6,477	
258	4,666.67	6,469	
259	4,666.64	6,461	
260	4,666.61	6,453	

TABLE 2. SLOPE-ELEVATION-STORAGE TABLE (continued)

PAINTED ROCKS RESERVOIR - BELOW BOAT RAMP

DISTANCE feet	ELEVATION feet	STORAGE acre-feet	NOTES
261	4,666.65	6,464	
262	4,666.68	6,472	
263	4,666.72	6,483	
264	4,666.75	6,491	
265	4,666.79	6,499	
266	4,666.82	6,510	
267	4,666.86	6,518	
268	4,666.89	6,529	
269	4,666.93	6,537	
270	4,666.96	6,548	
271	4,666.95	6,545	
272	4,666.95	6,545	
273	4,666.94	6,542	
274	4,666.94	6,542	
275	4,666.93	6,540	
276	4,666.92	6,537	
277	4,666.92	6,537	
278	4,666.91	6,534	
279	4,666.91	6,534	
280	4,666.90	6,531	
281	4,666.89	6,529	
282	4,666.88	6,526	
283	4,666.86	6,521	
284	4,666.85	6,518	
285	4,666.84	6,515	
286	4,666.83	6,512	
287	4,666.82	6,510	
288	4,666.80	6,504	
289	4,666.79	6,502	
290	4,666.78	6,499	
291	4,666.77	6,496	
292	4,666.77	6,496	
293	4,666.76	6,493	
294	4,666.75	6,491	
295	4,666.75	6,491	
296	4,666.74	6,488	
297	4,666.73	6,485	
298	4,666.72	6,483	
299	4,666.72	6,483	
300	4,666.71	6,480	
301	4,666.72	6,483	
302	4,666.72	6,483	
303	4,666.73	6,485	
304	4,666.74	6,488	
305	4,666.75	6,488	
306	4,666.75	6,491	
307	4,666.76	6,493	
308	4,666.77	6,496	
309	4,666.77	6,496	
310	4,666.78	6,499	
311	4,666.78	6,499	
312	4,666.78	6,499	
313	4,666.77	6,496	
314	4,666.77	6,496	
315	4,666.77	6,496	
316	4,666.77	6,496	
317	4,666.77	6,496	
318	4,666.76	6,493	
319	4,666.76	6,493	
320	4,666.76	6,493	
321	4,666.69	6,474	
322	4,666.63	6,458	
323	4,666.56	6,439	
324	4,666.49	6,420	
325	4,666.43	6,404	
326	4,666.36	6,385	
327	4,666.29	6,366	
328	4,666.22	6,347	
329	4,666.16	6,331	
330	4,666.09	6,312	
331	4,665.95	6,274	
332	4,665.81	6,236	
333	4,665.67	6,198	
334	4,665.54	6,163	
335	4,665.40	6,130	
336	4,665.26	6,098	
337	4,665.12	6,067	
338	4,664.98	6,035	
339	4,664.84	6,004	
340	4,664.71	5,974	
341	4,664.57	5,943	
342	4,664.43	5,911	
343	4,664.29	5,880	

TABLE 3. ACTIVE STORAGE IN ACRE-FEET

PAINTED ROCKS DAM

Elevation	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
4625						0	9	17	26	35
4626	43	52	60	69	78	87	95	104	113	121
4627	130	139	147	156	165	174	182	191	200	208
4628	217	226	234	243	252	261	269	278	287	295
4629	304	313	321	330	339	348	356	365	374	382
4630	391	400	408	417	425	434	443	451	460	468
4631	477	486	494	503	512	521	529	538	547	555
4632	564	572	581	589	598	607	616	624	633	642
4633	651	660	668	677	685	694	703	711	720	728
4634	737	746	754	763	771	780	788	797	806	815
4635	824	832	841	850	858	867	880	893	906	919
4636	932	945	958	971	984	997	1010	1023	1036	1049
4637	1062	1075	1088	1101	1114	1127	1140	1153	1166	1179
4638	1192	1205	1218	1231	1244	1257	1270	1283	1296	1309
4639	1322	1335	1348	1361	1374	1387	1400	1413	1426	1439
4640	1452	1465	1478	1491	1504	1517	1530	1543	1556	1569
4641	1582	1595	1608	1621	1634	1647	1660	1673	1686	1699
4642	1712	1725	1738	1751	1764	1777	1790	1803	1816	1829
4643	1842	1855	1868	1881	1894	1907	1920	1933	1946	1959
4644	1972	1985	1998	2011	2024	2037	2050	2063	2076	2089
4645	2102	2115	2128	2141	2154	2167	2184	2202	2219	2236
4646	2254	2271	2289	2306	2323	2341	2358	2375	2392	2410
4647	2427	2444	2462	2479	2497	2514	2531	2549	2566	2584
4648	2601	2618	2636	2653	2670	2688	2705	2722	2739	2757
4649	2774	2791	2809	2826	2844	2861	2878	2896	2913	2931
4650	2948	2965	2983	3000	3017	3035	3052	3069	3086	3104
4651	3121	3138	3156	3173	3190	3208	3225	3242	3259	3277
4652	3294	3311	3329	3346	3364	3381	3398	3416	3433	3451
4653	3468	3485	3503	3520	3537	3555	3572	3589	3606	3624
4654	3641	3658	3676	3693	3711	3728	3745	3763	3780	3798
4655	3815	3832	3849	3866	3884	3901	3924	3946	3969	3991
4656	4014	4036	4059	4081	4104	4126	4149	4171	4194	4216
4657	4239	4261	4284	4306	4329	4351	4374	4396	4419	4441
4658	4464	4487	4509	4532	4554	4577	4599	4622	4644	4667
4659	4689	4712	4734	4757	4779	4802	4824	4847	4869	4892
4660	4914	4937	4959	4982	5004	5027	5050	5072	5095	5117
4661	5140	5163	5185	5208	5230	5253	5275	5298	5320	5343
4662	5365	5387	5410	5432	5455	5477	5500	5522	5545	5567
4663	5590	5613	5635	5658	5680	5703	5725	5748	5770	5793
4664	5815	5837	5860	5882	5905	5927	5950	5972	5995	6017
4665	6040	6062	6085	6107	6130	6152	6179	6206	6233	6260
4666	6288	6315	6342	6369	6396	6424	6451	6478	6505	6532
4667	6559	6586	6613	6640	6667	6694	6721	6748	6775	6802
4668	6829	6856	6883	6910	6937	6965	6992	7018	7045	7072
4669	7100	7127	7154	7181	7208	7236	7263	7290	7317	7344
4670	7371	7398	7425	7452	7479	7507	7533	7560	7587	7614

TABLE 3. ACTIVE STORAGE IN ACRE-FEET (continued)

PAINTED ROCKS DAM

Elevation	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
4671	7642	7669	7696	7723	7750	7777	7804	7831	7858	7885
4672	7913	7940	7967	7994	8021	8048	8075	8102	8129	8156
4673	8183	8210	8237	8264	8291	8318	8345	8372	8399	8426
4674	8453	8480	8507	8534	8561	8588	8616	8643	8670	8697
4675	8724	8752	8779	8806	8833	8860	8892	8925	8957	8990
4676	9022	9054	9087	9119	9152	9184	9217	9249	9282	9314
4677	9347	9379	9412	9444	9477	9509	9541	9574	9606	9639
4678	9671	9703	9736	9768	9801	9833	9865	9898	9930	9963
4679	9995	10028	10060	10093	10125	10158	10190	10223	10255	10288
4680	10320	10352	10385	10417	10450	10482	10514	10547	10579	10612
4681	10644	10676	10709	10741	10774	10806	10838	10871	10903	10936
4682	10968	11000	11033	11065	11098	11130	11162	11195	11227	11260
4683	11292	11325	11357	11390	11422	11455	11487	11520	11552	11585
4684	11617	11649	11682	11714	11747	11779	11811	11844	11876	11909
4685	11941	11973	12006	12038	12071	12103	12141	12179	12217	12255
4686	12293	12331	12369	12407	12445	12483	12520	12558	12596	12634
4687	12672	12710	12748	12786	12824	12862	12899	12937	12975	13013
4688	13051	13089	13127	13165	13203	13241	13279	13317	13355	13393
4689	13431	13469	13507	13545	13583	13621	13658	13696	13734	13772
4690	13810	13848	13886	13924	13962	14000	14037	14075	14113	14151
4691	14189	14227	14265	14303	14341	14379	14416	14454	14492	14530
4692	14568	14606	14644	14682	14720	14758	14795	14833	14871	14909
4693	14947	14985	15023	15061	15099	15137	15175	15213	15251	15289
4694	15327	15365	15403	15441	15479	15517	15554	15592	15630	15668
4695	15706	15743	15781	15819	15857	15895	15940	15985	16030	16075
4696	16121	16166	16211	16256	16301	16346	16391	16436	16481	16526
4697	16571	16616	16661	16706	16751	16796	16841	16886	16931	16976
4698	17021	17066	17111	17156	17201	17246	17292	17337	17382	17427
4699	17472	17517	17562	17607	17652	17697	17743	17788	17833	17878
4700	17923	17968	18013	18058	18103	18148	18194	18239	18284	18329
4701	18374	18419	18464	18509	18554	18599	18644	18689	18734	18779
4702	18824	18869	18914	18959	19004	19049	19095	19140	19185	19230
4703	19275	19320	19365	19410	19455	19500	19546	19591	19636	19681
4704	19726	19771	19816	19861	19906	19951	19996	20041	20086	20131
4705	20176	20222	20267	20312	20357	20402	20454	20507	20559	20612
4706	20664	20716	20769	20821	20874	20926	20978	21031	21083	21136
4707	21188	21240	21293	21345	21398	21450	21502	21555	21607	21660
4708	21713	21765	21818	21870	21923	21975	22027	22080	22132	22185
4709	22237	22289	22342	22394	22447	22499	22551	22604	22656	22709
4710	22761	22813	22866	22918	22971	23023	23075	23128	23180	23233
4711	23285	23337	23390	23442	23495	23547	23599	23652	23704	23757
4712	23809	23861	23914	23966	24019	24071	24123	24176	24228	24281
4713	24334	24386	24439	24491	24544	24596	24648	24701	24753	24806
4714	24858	24910	24963	25015	25068	25120	25172	25225	25277	25330
4715	25382	25435	25487	25539	25592	25644	25705	25765	25826	25887

TABLE 3. ACTIVE STORAGE IN ACRE-FEET (continued)

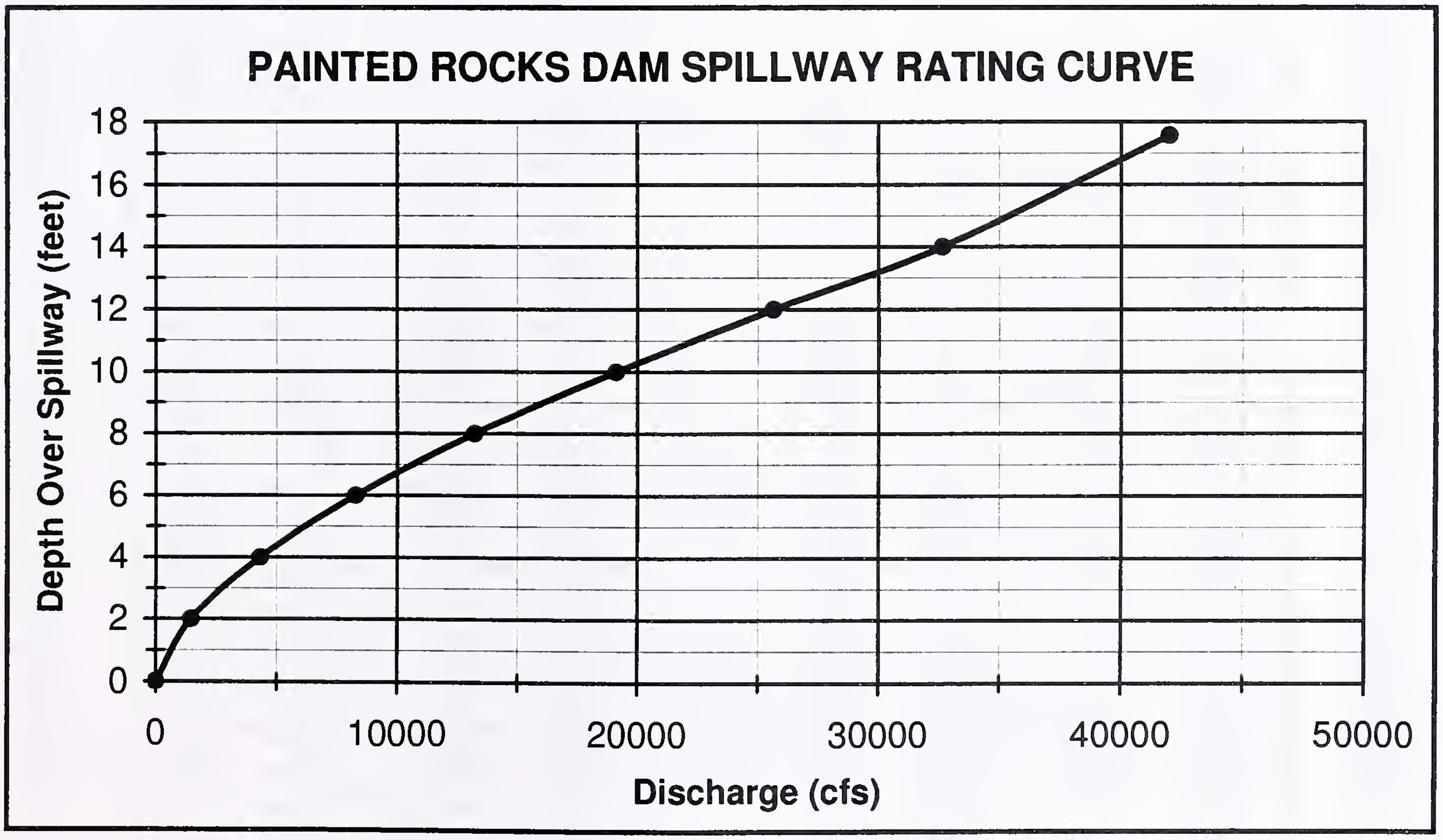
PAINTED ROCKS DAM

Elevation	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
4716	25947	26008	26068	26129	26189	26250	26311	26371	26432	26492
4717	26553	26614	26674	26735	26795	26856	26917	26977	27038	27098
4718	27159	27220	27280	27341	27401	27462	27523	27583	27644	27704
4719	27766	27827	27887	27948	28008	28069	28130	28190	28251	28311
4720	28372	28433	28493	28554	28614	28675	28736	28796	28857	28917
4721	28978	29039	29099	29160	29220	29281	29281	29281	29281	29281
4722	29584	29645	29705	29766	29826	29887	29948	30008	30069	30129
4723	30190	30251	30311	30372	30433	30494	30554	30615	30676	30736
4724	30797	30858	30918	30979	31040	31101	31161	31222	31283	31343
4725	31403	31464	31524	31585	31645	31706	31775	31845	31914	31984
4726	32053	32122	32192	32261	32331	32400	32469	32539	32608	32678
4727	32747	32816	32886	32955	33025	33094	33163	33233	33302	33372
4728	33441	33510	33580	33649	33719	33788	33857	33927	33996	34066
4729	34135	34204	34274	34343	34413	34482	34551	34621	34690	34760
4730	34829	34898	34968	35037	35107	35176				

TABLE 4. SPILLWAY DISCHARGE

PAINTED ROCKS DAM

Depth Over Crest (feet)	Elevation (feet)	Discharge (cfs)	Comments
0.0	4725.5	0	Spillway Crest
2.0	4727.5	1460	
4.0	4729.5	4320	
6.0	4731.5	8270	
8.0	4733.5	13220	
10.0	4735.5	19120	
12.0	4737.5	25640	
14.0	4739.5	32640	
17.6	4743.07	42000	Dam Crest



Note: Data from the Corps of Engineers Phase 1 Inspection Report (1980).

TABLE 5. WEST FORK BITTERROOT RIVER RATING TABLE

(USGS Gage 12342500 -- West Fork Bitterroot Near Connor, MT)
(Gage Located On Right Bank 0.6 Miles Below Reservoir)

GAGE HEIGHT (Feet)	DISCHARGE (Cubic Feet Per Second) 0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.5	7.50	7.83	8.18	8.54	8.90	9.28	9.67	10.70	10.48	10.99
0.6	11.34	11.79	12.25	12.72	13.21	13.71	14.22	14.75	15.29	15.85
0.7	16.41	17.00	17.60	18.21	18.81	19.48	20.14	20.81	21.50	22.21
0.8	22.94	23.68	24.43	35.21	26.00	26.81	27.61	28.68	29.34	30.23
0.9	31.13	32.05	32.99	33.95	34.92	35.92	36.94	37.96	19.84	40.12
1.0	41.23	42.35	43.49	44.66	45.85	47.05	48.30	49.56	50.84	52.14
1.1	53.47	54.83	56.28	57.60	59.03	60.48	61.96	63.46	64.99	66.54
1.2	68.12	69.73	71.37	73.03	74.72	76.43	78.18	79.95	81.75	83.58
1.3	85.44	87.33	89.25	91.20	93.18	85.19	97.23	99.00	101.40	103.50
1.4	105.70	107.90	110.10	112.40	114.70	117.00	119.40	121.80	124.20	126.70
1.5	129.20	131.70	134.30	136.90	135.60	142.20	144.90	147.70	150.50	153.30
1.6	156.20	159.10	162.00	165.00	168.00	171.10	147.20	177.30	180.50	183.70
1.7	187.00	190.40	193.80	197.30	200.80	204.30	207.50	211.40	215.00	218.60
1.8	222.20	225.90	229.60	233.30	237.10	240.90	244.70	248.50	252.40	256.30
1.9	260.20	264.10	268.10	272.10	276.10	280.10	284.20	288.30	292.40	296.60
2.0	300.80	605.00	309.20	313.80	317.70	322.00	326.40	330.70	335.10	339.50
2.1	344.00	348.40	352.90	357.80	362.00	366.50	371.10	375.70	380.40	385.40
2.2	389.70	394.50	399.20	404.00	408.80	413.60	418.40	423.30	428.20	433.10
2.3	338.10	343.00	448.00	453.20	458.10	463.70	468.30	473.40	478.50	483.70
2.4	288.30	494.10	499.40	506.70	509.90	515.30	520.60	526.00	531.40	536.80
2.5	542.20	547.70	553.20	558.70	564.30	569.80	575.10	581.00	586.70	592.30
2.6	598.00	603.70	609.50	615.20	621.00	626.80	632.70	638.50	644.40	650.30
2.7	656.20	662.20	668.20	674.20	680.20	686.30	692.30	698.40	704.60	710.70
2.8	716.90	723.10	729.30	735.50	741.80	748.10	754.40	760.70	767.10	773.50
2.9	779.90	786.30	792.80	799.30	805.80	812.30	818.90	825.40	832.00	838.60
3.0	845.30	852.00	858.60	865.40	872.10	878.90	885.60	892.50	899.30	906.10
3.1	913.00	919.90	926.90	933.80	940.00	947.80	954.80	961.80	964.90	976.00
3.2	983.10	990.20	997.40	1005.00	1012.00	1019.00	1026.00	1036.00	1041.00	1048.00
3.3	1055.00	1063.00	1070.00	1078.00	1085.00	1093.00	1100.00	1107.00	1115.00	1123.00
3.4	1130.00	1138.00	1145.00	1153.00	1161.00	1168.00	1176.00	1184.00	1192.00	1199.00
3.5	1207.00	1215.00	1223.00	1231.00	1238.00	1246.00	1254.00	1262.00	1270.00	1278.00
3.6	1286.00	1294.00	1302.00	1310.00	1319.00	1327.00	1335.00	1343.00	1351.00	1360.00
3.7	1368.00	1376.00	1384.00	1393.00	1401.00	1409.00	1418.00	1426.00	1435.00	1443.00
3.8	1451.00	1460.00	1468.00	1477.00	1486.00	1494.00	1503.00	1511.00	1520.00	1529.00
3.9	1537.00	1546.00	1555.00	1564.00	1572.00	1581.00	1590.00	1599.00	1608.00	1617.00
4.0	1625.00	1634.00	1643.00	1652.00	1661.00	1670.00	1679.00	1688.00	1698.00	1707.00
4.1	1716.00	1725.00	1734.00	1743.00	1753.00	1762.00	1771.00	1780.00	1790.00	1799.00
4.2	1808.00	1818.00	1827.00	1836.00	1846.00	1855.00	1865.00	1874.00	1884.00	1893.00
4.3	1903.00	1912.00	1922.00	1932.00	1941.00	1951.00	1961.00	1970.00	1980.00	1990.00
4.4	2000.00	2018.00	2019.00	2029.00	2039.00	2049.00	2059.00	2069.00	2078.00	2089.00
4.5	2099.00	2109.00	2119.00	2129.00	2139.00	2149.00	2159.00	2169.00	2179.00	2190.00
4.6	2200.00	2210.00	2220.00	2231.00	2241.00	2251.00	2261.00	2272.00	2282.00	2293.00
4.7	2303.00	2313.00	2324.00	2334.00	2345.00	2355.00	2366.00	2377.00	2387.00	2398.00
4.8	2408.00	2419.00	2430.00	2440.00	2451.00	2462.00	2743.00	2483.00	2494.00	2505.00
4.9	2516.00	2527.00	2538.00	2548.00	2559.00	2570.00	2581.00	2592.00	2603.00	2614.00
5.0	2625.00	2636.00	2647.00	2658.00	2670.00	2681.00	2692.00	2703.00	2714.00	2726.00
5.1	2737.00	2748.00	2760.00	2771.00	2782.00	2794.00	2805.00	2816.00	2828.00	2839.00
5.0	2851.00	2862.00	2874.00	2885.00	2897.00	2908.00	2920.00	2931.00	2943.00	2955.00
5.3	2966.00	2978.00	2990.00	3002.00	3013.00	3025.00	3037.00	3049.00	3061.00	3072.00
5.4	3084.00	3096.00	3108.00	3120.00	3132.00	3144.00	3156.00	3168.00	3180.00	3192.00
5.5	3204.00	3216.00	3228.00	3240.00	3253.00	3265.00	3277.00	3289.00	3301.00	3314.00
5.6	3326.00	3338.00	3351.00	3363.00	3375.00	3388.00	3400.00	3413.00	3425.00	3438.00
5.7	3450.00									

Table created 6/15/2001 by U.S. Department Of Interior, Geological Survey, Water Resources Division.
Rating Table No. 7.0

TABLE 6. WEST FORK BITTERROOT RIVER RATING TABLE

(Gage Located Above Reservoir At Coal Creek Bridge)

GAGE HEIGHT (Feet)	DISCHARGE (Cubic Feet Per Second)									
	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.2	0.95	1.07	1.20	1.33	1.48	1.63	1.79	1.96	2.14	2.33
0.3	2.53	2.74	2.96	3.19	3.43	3.68	3.93	4.20	4.48	4.77
0.4	5.07	5.39	5.71	6.04	6.39	6.74	7.11	7.49	7.88	8.28
0.5	8.69	9.12	9.56	10.01	10.47	10.94	11.43	11.93	12.44	12.97
0.6	13.50	14.05	14.61	15.19	15.78	16.38	16.99	17.62	18.26	18.92
0.7	19.59	20.27	20.97	21.68	22.40	23.14	23.89	24.66	25.44	26.23
0.8	27.04	27.86	28.70	29.55	30.42	31.30	32.20	33.11	34.03	34.98
0.9	35.93	36.90	37.89	38.89	39.91	40.94	41.99	43.05	44.13	45.23
1.0	46.34	47.46	48.61	49.76	50.94	52.13	53.34	54.56	55.80	57.05
1.1	58.33	59.61	60.92	62.24	63.58	64.93	66.30	67.69	69.10	70.52
1.2	71.96	73.41	74.89	76.38	77.88	79.41	80.95	82.51	84.09	85.68
1.3	87.30	88.93	90.57	92.24	93.92	95.62	97.34	99.08	100.83	102.61
1.4	104.40	106.21	108.03	109.88	111.74	113.63	115.53	117.45	119.38	121.34
1.5	123.32	125.31	127.32	129.35	131.40	133.47	135.56	137.67	139.79	141.94
1.6	144.10	146.29	148.49	150.71	152.96	155.22	157.50	159.80	162.12	164.46
1.7	166.81	169.19	171.59	174.01	176.45	178.91	181.38	183.88	186.40	188.94
1.8	191.50	194.07	196.67	199.29	201.93	204.59	207.27	209.97	212.69	215.43
1.9	218.19	220.98	223.78	226.60	229.45	232.31	235.20	238.11	241.03	243.98
2.0	246.95	249.95	252.96	255.99	259.05	262.12	265.22	268.34	271.48	274.64
2.1	277.82	281.03	284.25	287.50	290.77	294.06	297.37	300.71	304.06	307.44
2.2	310.84	314.26	317.71	321.17	324.66	328.17	331.70	335.26	338.83	342.43
2.3	346.05	349.69	353.36	357.05	360.76	364.49	368.25	372.02	375.82	379.65
2.4	383.49	387.36	391.25	395.17	399.11	403.07	407.05	411.05	415.08	419.13
2.5	423.21	427.31	431.43	435.57	439.74	443.93	448.15	452.38	456.64	460.93
2.6	465.24	469.57	473.92	478.30	482.70	487.13	491.58	496.05	500.55	505.07
2.7	509.61	514.18	518.77	523.39	528.03	532.69	537.38	542.09	546.83	551.59
2.8	556.37	561.18	566.02	570.87	575.76	580.66	585.59	590.55	595.53	600.53
2.9	605.56	610.61	615.69	620.79	625.92	631.07	636.25	641.45	646.67	651.92
3.0	657.20	662.50	667.83	673.18	678.55	683.95	689.38	694.83	700.31	705.81
3.1	711.33	716.89	722.46	728.07	733.69	739.35	745.03	750.73	756.46	762.21
3.2	768.00	773.80	779.63	785.49	791.37	797.28	803.22	809.18	815.17	821.18
3.3	827.22	833.28	839.37	845.49	851.63	857.80	863.99	870.21	876.46	882.73
3.4	889.03	895.36	901.71	908.08	914.49	920.92	927.38	933.86	940.37	946.91
3.5	953.47	960.06	966.67	973.32	979.99	986.68	993.40	1000.15	1006.93	1013.73
3.6	1020.56	1027.42	1034.30	1041.22	1048.15	1055.12	1062.11	1069.13	1076.17	1083.25
3.7	1090.35	1097.47	1104.63	1111.81	1119.02	1126.26	1133.52	1140.81	1148.13	1155.48
3.8	1162.85	1170.25	1177.68	1185.13	1192.62	1200.13	1207.67	1215.23	1222.83	1230.45
3.9	1238.10	1245.78	1253.48	1261.21	1268.98	1276.76	1284.58	1292.43	1300.30	1308.20
4.0	1316.13	1324.08	1332.07	1340.08	1348.12	1356.19	1364.29	1372.42	1380.57	1388.75
4.1	1396.96	1405.20	1413.47	1421.77	1430.09	1438.44	1446.83	1455.24	1463.67	1472.14
4.2	1480.64	1489.16	1497.71	1506.30	1514.91	1523.55	1532.21	1540.91	1549.64	1558.39
4.3	1567.18	1575.99	1584.83	1593.70	1602.60	1611.53	1620.49	1629.47	1638.49	1647.53
4.4	1656.61	1665.71	1674.84	1684.00	1693.20	1702.42	1711.67	1720.94	1730.25	1739.59
4.5	1748.96	1758.36	1767.78	1777.24	1786.72	1796.24	1805.78	1815.36	1824.96	1834.60
4.6	1844.26	1853.95	1863.67	1873.43	1883.21	1893.02	1902.86	1912.74	1922.64	1932.57
4.7	1942.53	1952.53	1962.55	1972.60	1982.68	1992.79	2002.94	2013.11	2023.31	2033.55
4.8	2043.81	2054.10	2064.43	2074.78	2085.17	2095.58	2106.03	2116.50	2127.01	2137.55
4.9	2148.11	2158.71	2169.34	2180.00	2190.69	2201.41	2212.16	2222.94	2233.75	2244.60
5.0	2255.47	2266.38	2277.31	2288.28	2299.28	2310.30	2321.36	2332.45	2343.57	2354.73

Table created 3/29/2000 by Ron Roman, Montana DNRC -- Water Resources Division.
Rating Table No. 2
The regression equation of log discharge on log gage height is: LOG Q = 2.41 x LOG (Gage Height) + 1.67
This equation has an r-squared value of 1.00
The arithmetic form of this equation is: Q = 44.34 x ((GAGE HEIGHT)** 2.41)

TABLE 6. BLUE JOINT CREEK RATING TABLE

GAGE HEIGHT (Feet)	DISCHARGE (Cubic Feet Per Second)									
	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0						11.90	12.20	12.50	12.93	13.37
0.1	13.80	14.17	14.54	14.91	15.28	15.65	16.02	16.39	16.76	17.13
0.2	17.50	18.00	18.50	19.00	19.50	20.00	20.50	21.00	21.50	22.00
0.3	22.50	23.06	23.62	24.18	24.74	25.30	25.86	26.42	26.98	27.54
0.4	28.10	28.79	29.48	30.17	30.86	31.55	32.24	32.93	33.62	34.31
0.5	35.00	35.76	36.52	37.28	38.04	38.80	39.56	40.32	41.08	41.84
0.6	42.60	43.54	44.48	45.42	46.36	47.30	48.24	49.18	50.12	51.06
0.7	52.00	52.99	53.98	54.97	55.96	56.95	57.94	58.93	59.92	60.91
0.8	61.90	62.97	64.04	65.11	66.18	67.25	68.32	69.39	70.46	71.53
0.9	72.60	73.94	75.28	76.62	77.96	79.30	80.64	81.98	83.32	84.66
1.0	86.00	87.40	88.80	90.20	91.60	93.00	94.40	95.80	97.20	98.60
1.1	100.00	101.75	103.50	105.25	107.00	108.75	110.50	112.25	114.00	115.75
1.2	117.50	118.88	120.26	121.64	123.02	124.40	125.78	127.16	128.54	129.92
1.3	131.30	133.77	136.24	138.71	141.18	143.65	146.12	148.59	151.06	153.53
1.4	156.00	158.10	160.20	162.30	164.40	166.50	168.60	170.70	172.80	174.90
1.5	177.00	179.20	181.40	183.60	185.80	188.00	190.20	192.40	194.60	196.80
1.6	199.00	201.23	203.46	205.69	207.92	210.15	212.38	214.61	216.84	219.07
1.7	221.30	223.61	225.92	228.23	230.54	232.85	235.16	237.47	239.78	242.09
1.8	244.40	246.66	248.92	251.18	253.44	255.70	257.96	260.22	262.48	264.74
1.9	267.00	269.40	271.80	274.20	276.60	279.00	281.40	283.80	286.20	288.60
2.0	291.00	293.40	295.80	298.20	300.60	303.00	305.40	307.80	310.20	312.60
2.1	315.00	317.40	319.80	322.20	324.60	327.00	329.40	331.80	334.20	336.60
2.2	339.00	341.50	344.00	346.50	349.00	351.50	354.00	356.50	359.00	361.50
2.3	364.00	366.50	369.00	371.50	374.00	376.50	379.00	381.50	384.00	386.50

Table created 11/9/2001 by Ron Roman, Montana DNRC -- Water Resources Division.
Rating Table No. 2

TABLE 8. OVERWHICH CREEK RATING TABLE

GAGE HEIGHT (Feet)	DISCHARGE (Cubic Feet Per Second)									
	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.2	0.12	0.14	0.16	0.19	0.22	0.25	0.29	0.33	0.38	0.42
0.3	0.48	0.53	0.60	0.66	0.74	0.81	0.90	0.99	1.08	1.19
0.4	1.29	1.41	1.53	1.66	1.80	1.95	2.10	2.27	2.44	2.62
0.5	2.81	3.01	3.22	3.44	3.67	3.91	4.16	4.42	4.70	4.98
0.6	5.28	5.59	5.92	6.26	6.61	6.97	7.35	7.75	8.15	8.58
0.7	9.02	9.47	9.94	10.43	10.93	11.45	11.99	12.55	13.12	13.71
0.8	14.33	14.96	15.61	16.28	16.97	17.68	18.41	19.16	19.94	20.73
0.9	21.55	22.39	23.26	24.15	25.06	26.00	26.96	27.94	28.96	29.99
1.0	31.06	32.15	33.27	34.41	35.58	36.78	38.01	39.27	40.56	41.87
1.1	43.22	44.60	46.01	47.45	48.92	50.43	51.96	53.53	55.14	56.77
1.2	58.44	60.15	61.89	63.67	65.48	67.33	69.22	71.14	73.10	75.10
1.3	77.14	79.22	81.34	83.49	85.69	87.93	90.21	92.53	94.89	97.30
1.4	99.75	102.24	104.78	107.36	109.98	112.65	115.37	118.13	120.94	123.80
1.5	126.71	129.66	132.66	135.71	138.81	141.97	145.17	148.42	151.72	155.08
1.6	158.49	161.95	165.47	169.03	172.66	176.34	180.07	183.86	187.71	191.61
1.7	195.57	199.59	203.66	207.80	211.99	216.25	220.57	224.94	229.38	233.88
1.8	238.44	243.07	247.76	252.51	257.32	262.21	267.15	272.17	277.25	282.40
1.9	287.61	292.90	298.25	303.67	309.16	314.72	320.35	326.06	331.83	337.68
2.0	343.60	349.60	355.67	361.81	368.03	374.32	380.69	387.14	393.66	400.26
2.1	406.94	413.70	420.54	427.46	434.46	441.54	448.70	455.95	463.28	470.69
2.2	478.18	485.76	493.43	501.18	509.02	516.94	524.95	533.05	541.24	549.51
2.3	557.88	566.33	574.88	583.52	592.25	601.07	609.99	619.00	628.11	637.30
2.4	646.60	655.99	665.48	675.06	684.74	694.53	704.40	714.38	724.46	734.64
2.5	744.93	755.31	765.80	776.39	787.08	797.88	808.78	819.79	830.90	842.13
2.6	853.45	864.89	876.44	888.09	899.86	911.73	923.72	935.82	948.03	960.35
2.7	972.79	985.34	998.00	1010.79	1023.68	1036.70	1049.83	1063.08	1076.45	1089.93
2.8	1103.54	1117.27	1131.12	1145.09	1159.18	1173.39	1187.73	1202.20	1216.79	1231.50
2.9	1246.34	1261.31	1276.40	1291.62	1306.97	1322.45	1338.07	1353.81	1369.68	1385.68
3.0	1401.82	1418.09	1434.50	1451.03	1467.71	1484.52	1501.00	1518.55	1534.77	1553.13
3.1	1570.63	1588.27	1606.05	1623.97	1642.04	1660.24	1678.59	1697.08	1715.72	1734.50
3.2	1753.43	1772.51	1791.73	1811.10	1830.62	1850.28	1870.10	1890.07	1910.19	1930.40
3.3	1950.88	1971.46	1992.19	2013.08	2034.12	2055.31	2076.67	2098.18	2119.85	2141.68
3.4	2163.67	2185.81	2208.12	2230.59	2253.23	2276.02	2298.98	2322.10	2345.39	2368.85
3.5	2392.47	2416.25	2440.21	2464.33	2788.63	2513.09	2537.72	2562.53	2587.51	2612.66
3.6	2637.98	2663.48	2689.15	2715.00	2741.02	2767.23	2793.61	2820.16	2846.90	2873.82
3.7	2900.91	2928.19	2955.65	2983.30	3011.13	3039.14	3067.33	3095.72	3124.28	3153.04
3.8	3181.98	3211.11	3240.44	3269.95	3299.65	3329.54	3359.63	3389.91	3420.38	3451.05
3.9	3481.91	3512.97	3544.22	3575.67	3607.32	3639.17	3671.22	3703.47	3768.57	3768.57
4.0	3801.42	3834.48	3867.74	3901.21	3934.88	3968.76	4002.85	4037.14	4071.64	4106.35

Table created 4/14/2000 by Ron Roman, Montana DNRC -- Water Resources Division.
Rating Table No. 2

The regression equation of log discharge on log gage height is:
LOG Q = 3.47 x LOG (GAGE HEIGHT) + 1.49
This equation has an r-squared value of 1.00

The arithmetic form of this equation is: Q = 31.06 x ((GAGE HEIGHT)** 3.47)

TABLE 9. SLATE CREEK RATING TABLE

GAGE HEIGHT (Feet)	DISCHARGE (Cubic Feet Per Second)									
	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.1	0.49	0.59	0.70	0.82	0.95	1.08	1.23	1.38	1.55	1.72
0.2	1.90	2.09	2.29	2.50	2.72	2.95	3.18	3.43	3.68	3.94
0.3	4.21	4.49	4.78	5.07	5.38	5.69	6.02	6.35	6.69	7.04
0.4	7.39	7.76	8.14	8.52	8.91	9.31	9.72	10.14	10.57	11.00
0.5	11.45	11.90	12.36	12.83	13.31	13.79	14.29	14.79	15.31	15.83
0.6	16.36	16.89	17.44	18.00	18.56	19.13	19.71	20.30	20.90	21.50
0.7	22.12	22.74	23.37	24.01	24.66	25.32	25.98	26.66	27.34	28.03
0.8	28.73	29.43	30.15	30.87	31.61	32.35	33.10	33.85	34.62	35.39
0.9	36.18	36.97	37.77	38.58	39.39	40.22	41.05	41.89	42.74	43.60
1.0	44.46	45.34	46.22	47.11	48.01	48.92	49.84	50.76	51.70	52.64
1.1	53.59	54.54	55.51	56.49	57.47	58.46	59.46	60.47	61.48	62.51
1.2	63.54	64.58	65.63	66.69	67.75	68.83	69.91	71.00	72.10	73.20
1.3	74.32	75.44	76.57	77.71	78.86	80.02	81.18	82.36	83.54	84.73
1.4	85.92	87.13	88.34	89.56	90.80	92.03	93.28	94.54	95.80	97.07
1.5	98.35	99.64	10.93	102.24	103.55	104.87	106.20	107.54	108.88	110.23
1.6	111.60	112.97	114.34	115.73	117.12	118.53	119.94	121.35	122.78	124.22
1.7	125.66	127.11	128.57	130.04	131.51	133.00	134.49	135.99	137.50	139.01
1.8	140.54	142.07	143.61	145.16	146.72	148.28	149.86	151.44	153.03	154.62
1.9	156.23	157.84	159.47	161.10	162.73	164.38	166.04	167.70	169.37	171.05

Table created 12/4/2001 by Ron Roman, Montana DNRC -- Water Resources Division.
Rating Table No. 3

The regression equation of log discharge on log gage height is:
LOG Q = 1.96 x LOG (GAGE HEIGHT) + 1.65
This equation has an r-squared value of 1.00

The arithmetic form of this equation is: Q = 44.46 x ((GAGE HEIGHT)** 1.96)

APPENDIX C

INSPECTION CHECKLIST

DEPARTMENT OF NATURAL RESOURCES AND CONSERVATION
DAM SAFETY INSPECTION REPORT

NAME OF DAM
DATE INSPECTED

INVENTORY NO. ______________
HAZARD CATEGORY __________
TYPE OF DAM _______________
YEAR BUILT _________________

OWNER _________________________
OPERATOR ______________________
STREAM _________________________
DRAINAGE AREA _________________

Reservoir Storage Status

	Water Surface Elevation (feet)	Storage (acre-feet)
At time of inspection	_________	_________
At spillway crest	_________	_________
At min. dam crest elevation	_________	_________

ITEM	YES	NO	REMARKS

1. EMBANKMENT

A. Crest -- Height= Length= Width=

(1) Any visual settlements?			
(2) Any misalignments?			
(3) Any cracking?			
(4) Any traffic damage?			
(5) Other?			

ITEM	YES	NO	REMARKS

1. **EMBANKMENT** (continued)

B. Upstream Face -- Slope=

(1) Any erosion?			
(2) Any longitudinal cracks?			
(3) Any transverse cracks?			
(4) Is riprap protection adequate?			
(5) Any stone deterioration?			
(6) Any visual settlement, slumps, sloughing, depressions or bulges?			
(7) Adequate grass cover?			
(8) Debris on the dam face?			
(9) Other?			

C. Downstream Face--Slope=

(1) Any erosion?			
(2) Any longitudinal cracks?			
(3) Any transverse cracks?			
(4) Any visual settlement, slumps, sloughing, depressions or bulges?			
(5) Is the toe drain dry?			
(6) Are the relief wells flowing?			
(7) Any boils at the toe?			
(8) Any seepage areas?			
(9) Any traffic or animal damage?			
(10) Any burrowing animals?			
(11) Adequate grass cover?			
(12) Other?			

D. Amount and Type of Vegetation on the Dam

.

ITEM	YES	NO	REMARKS

2. ABUTMENT CONTACTS

A) Any erosion?			
B) Any visual differential movement?			
C) Any cracks?			
D) Any seepage present?			
E) Other?			

3. OUTLET WORKS

A. Intake Structure -- Size=

(1) Any settlement?			
(2) Any tilting?			
(3) Do concrete surfaces show:			
a. Spalling?			
b. Cracking?			
c. Erosion?			
d. Exposed reinforcement?			
(4) Do joints show:			
a. Displacement or offset?			
b. Loss of joint material?			
c. Leakage?			
(5) Metal appurtenances:			
a. Any corrosion present?			
b. Any breakage present?			
(6) Trash rack?			
a. Condition?			
b. Anchor system secure?			
(7) Other?			

ITEM	YES	NO	REMARKS

3. OUTLET WORKS (continued)

B. Conduit -- Type = Size =

(1) Do concrete surfaces show:			
a. Spalling?			
b. Cracking?			
c. Erosion?			
d. Exposed reinforcement?			
(2) Do joints show:			
a. Displacement or offset?			
b. Loss of joint material?			
c. Leakage?			
(3) Is the conduit metal?			
a. Any corrosion present?			
b. Protective coatings adequate?			
(4) Is the conduit misaligned?			
(5) Any calcium deposits?			
(6) Other?			

C. Gates and Tower

(1) Gates:			
a. Size: Operating: b. Type: Operating:	Emergency: Emergency:		
(2) Controls operational?			
(3) Controls lubricated?			
(4) Operational problems?			
(5) Leakage around gates?			
(6) Condition of gate seals?			
(7) Any cavitation damage? If so, describe?			
(8) Describe air vent-size and condition.			

ITEM	YES	NO	REMARKS

3. OUTLET WORKS (continued)

C. Gates and Tower (continued)

(9) Is there a jet pump?			
a. Is it operational?			
b. Leakage?			
(10) Is the tower dry? _____ wet?			
(11) Any seepage in the tower?			
(12) Condition of the tower?			
(13) Any safety problems?			
(14) Ladder in good condition?			
(15) Condition of the gatehouse?			
(16) Emergency plan completed for the dam?			
a. Posted in the gatehouse?			
(17) Other?			

D. Stilling Basin

(1) Do concrete surfaces show:			
a. Spalling?			
b. Cracking?			
c. Erosion?			
d. Exposed reinforcement?			
(2) Do joints show:			
a. Displacement or offset?			
b. Loss of joint material?			
c. Leakage?			
(3) Do energy dissipaters show:			
a. Signs of deterioration?			
b. Are they covered with debris?			
(4) Other?			

ITEM	YES	NO	REMARKS

3. OUTLET WORKS (continued)

E. Downstream Channel

(1) Is the channel:			
a. Eroding or backcutting?			
b. Sloughing?			
c. Obstructed?			
(2) Is released water:			
a. Undercutting the outlet?			
b. Eroding the embankment?			
(3) Other?			

4. SPILLWAY

A. Description

(1) Location?			
(2) Type of Spillway?			
(3) Size of Spillway?			
(4) Spillway lining?			
(5) Is there a weir?			
(6) Is the spillway in good condition?			
(7) Any drains?			
a. Describe the condition of drains.			

B. Does spillway show:

(1) Any cracking concrete?			
(2) Any spalling concrete?			
(3) Any exposed reinforcement in the concrete?			
(4) Any erosion?			

ITEM	YES	NO	REMARKS

4. **SPILLWAY** (continued)

4. B. Does spillway show: (continued)

(5) Any slope sloughing?			
(6) Any obstructions?			
(7) Displacement or offset joints?			
(8) Loss of joint material?			
(9) Leakage at the joints?			
(10) Other?			

C. Do the energy dissipaters show:

(1) Signs of deterioration?			
(2) Any cracking?			
(3) Any spalling?			
(4) Any exposed reinforcement?			
(5) Are they covered with debris?			
(6) Other?			

D. Has release water:

(1) Eroded the embankment?			
(2) Undercut the outlet?			
(3) Eroded the downstream channel?			
(4) Other?			

E. Emergency Spillway

(1) Is there an emergency spillway?			(If YES, describe)

ITEM	YES	NO	REMARKS

5. RESERVOIR CONTROL

A) Recent upstream development?			
B) Recent downstream development?			
C) Slides in reservoir area?			
D) Change in reservoir operation?			
E) Large impoundment upstream?			
F) Any debris in the reservoir?			
G) Other?			

6. INSTRUMENTATION

A) List type(s) of instrumentation:			
B) In good condition?			
C) Read periodically?			
D) Is data available?			
E) Include all data gathered since last report.			

7. DOWNSTREAM CONDITION

A. Downstream Land Use.

This dam was inspected by:

Additional comments and recommendations.

APPENXIC D

DISTRUBUTION LIST

PAINTED ROCKS DISTRUBUTION LIST

	Number Of Copies
1. State Water Projects Bureau	7
Glen McDonald	
Kevin Smith	
Art Taylor (2)	
Bob Arrington	
Bob Clark	
Dolores Eustice	
2. DNRC Information Services Section	1
3 DNRC Missoula Regional Office	1
4. DNRC Dam Saftey	1
5. Water Users	3
Bill Strange – President	
Jack Phua – Vice President	
Gary Boyer -- Secretary	
6. Dam Operator	2
Dam Operator (Larry Schock)	
Gate house	
7. State Library – Attn: Roberta Gebhart	4
8. Extra	2
TOTAL	21

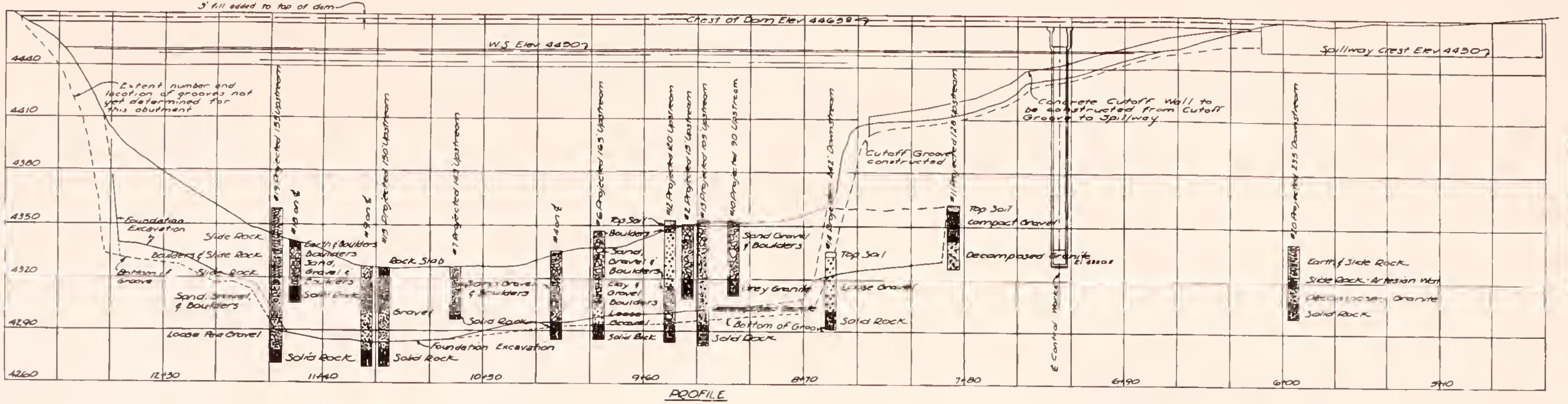
APPENDIX E

PROJECT DRAWINGS

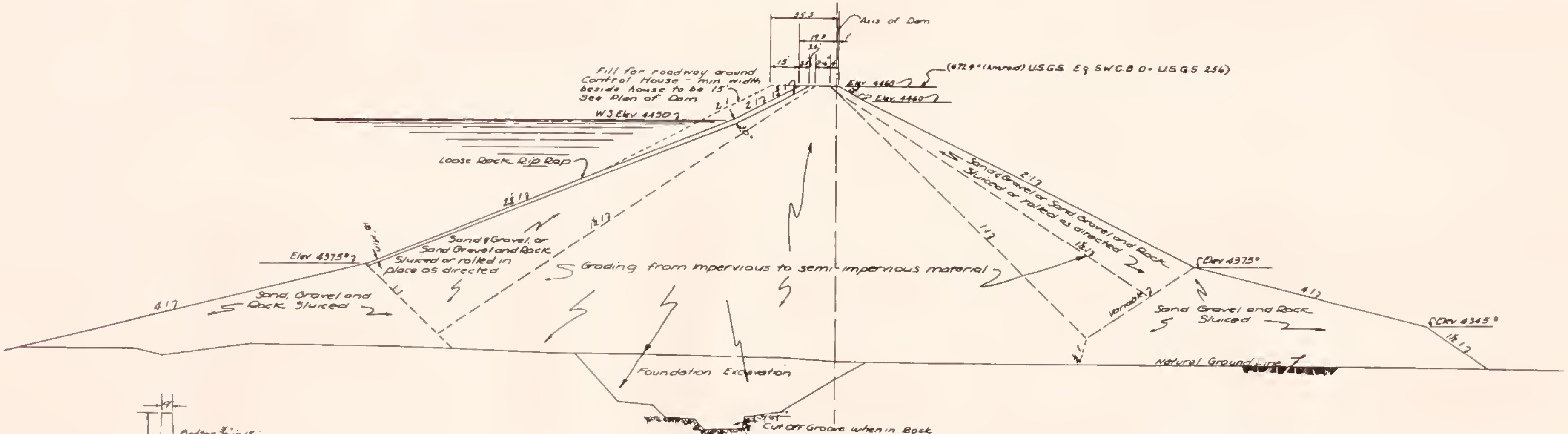
(NOTE: These reduced project drawings are design drawings and not "As Builts". These drawing should be used for reference only. The SWPB has the full size project drawings.)

(NOTE: To correct the enclosed 1938 and 1976 project drawing elevations to current corrected USGS elevations, add 275.5 feet.)

E2 2001

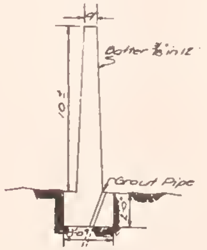


PROFILE
Scale - 1" = 30'

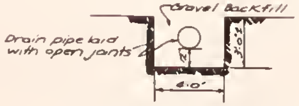

Axis of Dam
35.5
19.5
3.5'
15'
1'
Fill for roadway around Control House - min width beside house to be 15' See Plan of Dam
(4729 ± (Amended) U.S.G.S. Eq S.W.C.B 0 = U.S.G.S. 256)
Elev 4468
Elev 4466
W.S Elev 4450
2:1
2½:1
Loose Rock Rip Rap
2½:1
1½:1
Sand & Gravel, or Sand Gravel and Rock Sluiced or rolled in place as directed
Grading from impervious to semi-impervious material
Sand & Gravel or Sand Gravel and Rock Sluiced or rolled as directed
2:1
1:1
1½:1
Elev 4375
Elev 4375
4:1
Sand, Gravel and Rock Sluiced
Sand Gravel and Rock Sluiced
4:1
Variable
Elev 4345
1½:1
Natural Ground Line
Foundation Excavation
Cut off Groove when in Rock

TYPICAL MAXIMUM SECTION

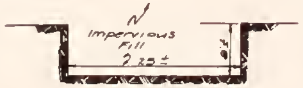
SCALE ~ 1" = 30'



DETAIL OF CUTOFF WALL



TYPICAL DRAIN TRENCH
Scale 1" = 4'



TYPICAL SECTION OF CUT OFF GROOVE

CAPACITY TABLE

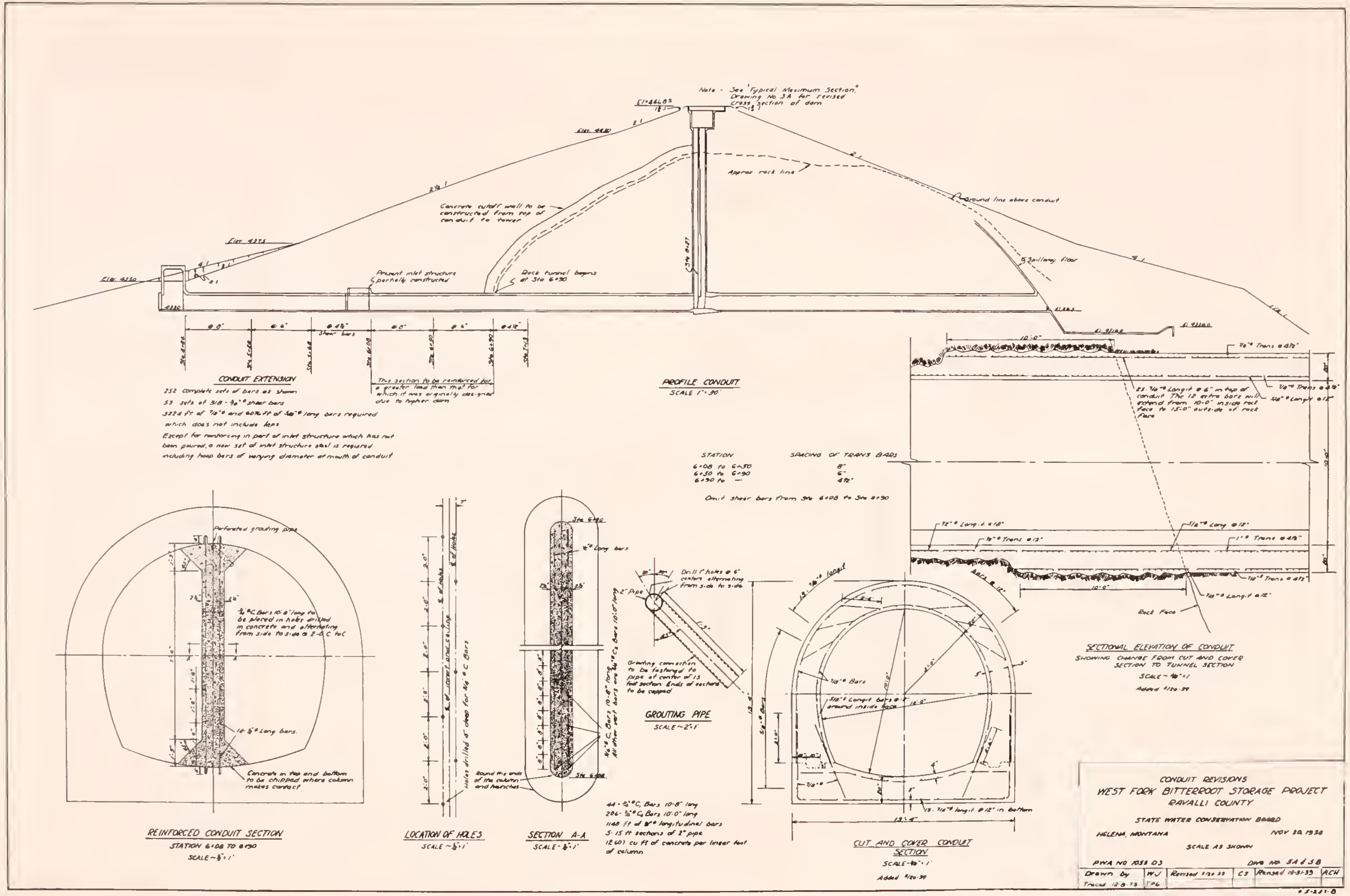
Contour Interval	Acres Flooded	Acre Feet Storage
4330	3	0
4340	33	162
4350	62	696
4360	112	1529
4370	149	2823
4380	193	4557
4390	252	6808
4400	299	9516
4410	341	12759
4420	417	16551
4430	486	21076
4440	557	26300
4450	635	32362
4460	732	39301
4470	824	47083
4480	905	55726
4490	1012	65309
4500	1113	75936

4350 OUTLET ELEV

DETAILS OF DAM
WEST FORK OF BITTERROOT
STORAGE PROJECT
RAVALLI COUNTY
STATE WATER CONSERVATION BOARD
HELENA, MONTANA OCT 1938
SCALE AS SHOWN
PWA NO 1053 DWG NO 3A

Drawn by NBB	Revised 9-13-39	SYW	Traced by JPS 11/29/39

6-8-387-8


Note - See "Typical Maximum Section" Drawing No 3A for revised cross section of dam
El 4446.5
Elev 4430
Elev 4375
Elev 4350
4330
2 1/2 : 1
2:1
Concrete cutoff wall to be constructed from top of conduit to tower
Present inlet structure partially constructed
Rock tunnel begins at Sta 6+90
Sta 8+27
Approx rock line
Ground line above conduit
Spillway floor
Sta 4+98
Sta 5+58
Sta 6+08
Sta 6+50
Sta 6+90
Sta 7+43
@ 8"
@ 6"
@ 4 1/2"
Shear bars
This section to be reinforced for a greater load than that for which it was originally designed due to higher dam
10'-0"
7/8" Trans @ 4 1/2"
25-7/8" Longit @ 6" in top of conduit. The 12 extra bars will extend from 10-0" inside rock face to 15-0" outside of rock face
7/8" Trans @ 4 1/2"
5/8" Longit @ 12"
1/2" Longit @ 18"
1/2" Trans @ 12"
5/8" Long @ 12"
1" Trans @ 4 1/2"
7/8" Trans @ 4 1/2"
7/8" Longit @ 12"
Rock Face
Perforated grouting pipe
3/4" C Bars 10'-8" long to be placed in holes drilled in concrete and alternating from side to side @ 2-0 C to C
14-5/8" Long bars.
Concrete in top and bottom to be chipped where column makes contact
Holes drilled 4" deep for 3/4" C Bars
Round the ends of the column and haunches
Sta 6+90
1/2" Long bars
Sta 6+08
3/4" C1 Bars 10-8" long
All other vert bars are 3/4" C2 Bars 10-0" long
2" Pipe
Drill 1" holes @ 6" centers alternating from side to side
Grouting connection to be fastened to pipe at center of 15 foot section. Ends of sections to be capped
19-7/8" longit
Bars @ 12"
7/8" Bars
5/8" Longit bars @ 12" around inside face
13'-4"
7/8" longit @ 12" in bottom
19'-4"

CONDUIT EXTENSION

252 complete sets of bars as shown
53 sets of 3/8 - 3/8" shear bars
3224 ft of 7/8" and 6076 ft of 5/8" long bars required which does not include laps
Except for reinforcing in part of inlet structure which has not been poured, a new set of inlet structure steel is required including hoop bars of varying diameter at mouth of conduit

PROFILE CONDUIT
SCALE 1"=30'

STATION	SPACING OF TRANS BARS
6+08 to 6+50	8"
6+50 to 6+90	6"
6+90 to —	4 1/2"

Omit shear bars from Sta 6+08 to Sta 8+30

SECTIONAL ELEVATION OF CONDUIT
SHOWING CHANGE FROM CUT AND COVER SECTION TO TUNNEL SECTION
SCALE ~ 1/8"=1'
Added 1/20-39

REINFORCED CONDUIT SECTION
STATION 6+08 TO 6+90
SCALE ~ 1/2"=1'

LOCATION OF HOLES
SCALE ~ 1/2"=1'

SECTION A-A
SCALE ~ 1/2"=1'

44 - 3/4" C1 Bars 10-8" long
206 - 3/4" C2 Bars 10'-0" long
1148 ft of 1/2" longitudinal bars
5 - 15 ft sections of 2" pipe
12.607 cu ft of concrete per linear foot of column

GROUTING PIPE
SCALE ~ 2"=1'

CUT AND COVER CONDUIT SECTION
SCALE ~ 1/2"=1'
Added 1/20-39

CONDUIT REVISIONS
WEST FORK BITTERROOT STORAGE PROJECT
RAVALLI COUNTY

STATE WATER CONSERVATION BOARD

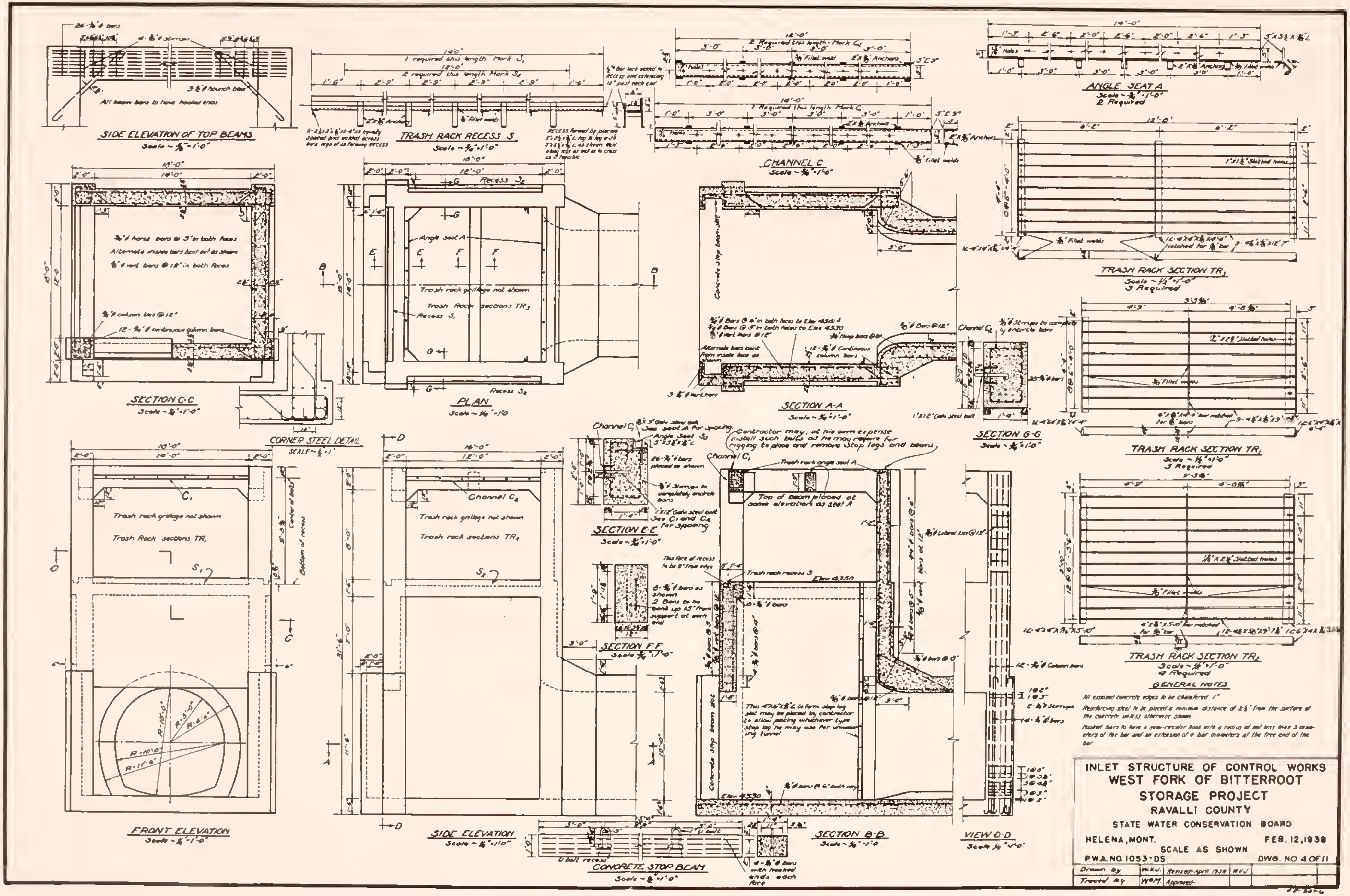
HELENA, MONTANA NOV 30 1938

SCALE AS SHOWN

PWA NO 1053 03 DWG NO 5A & 5B

Drawn by	WJ	Revised 1/20 39	CS	Revised 10-31-39	ACH
Traced 12-8-35	TPG				

0 5-251-8



GENERAL NOTES

All exposed concrete edges to be chamfered 1"

Reinforcing steel to be placed a minimum distance of 2½" from the surface of the concrete unless otherwise shown

Hooked bars to have a semi-circular hook with a radius of not less than 3 diameters of the bar and an extension of 4 bar diameters at the free end of the bar

INLET STRUCTURE OF CONTROL WORKS
WEST FORK OF BITTERROOT
STORAGE PROJECT
RAVALLI COUNTY

STATE WATER CONSERVATION BOARD

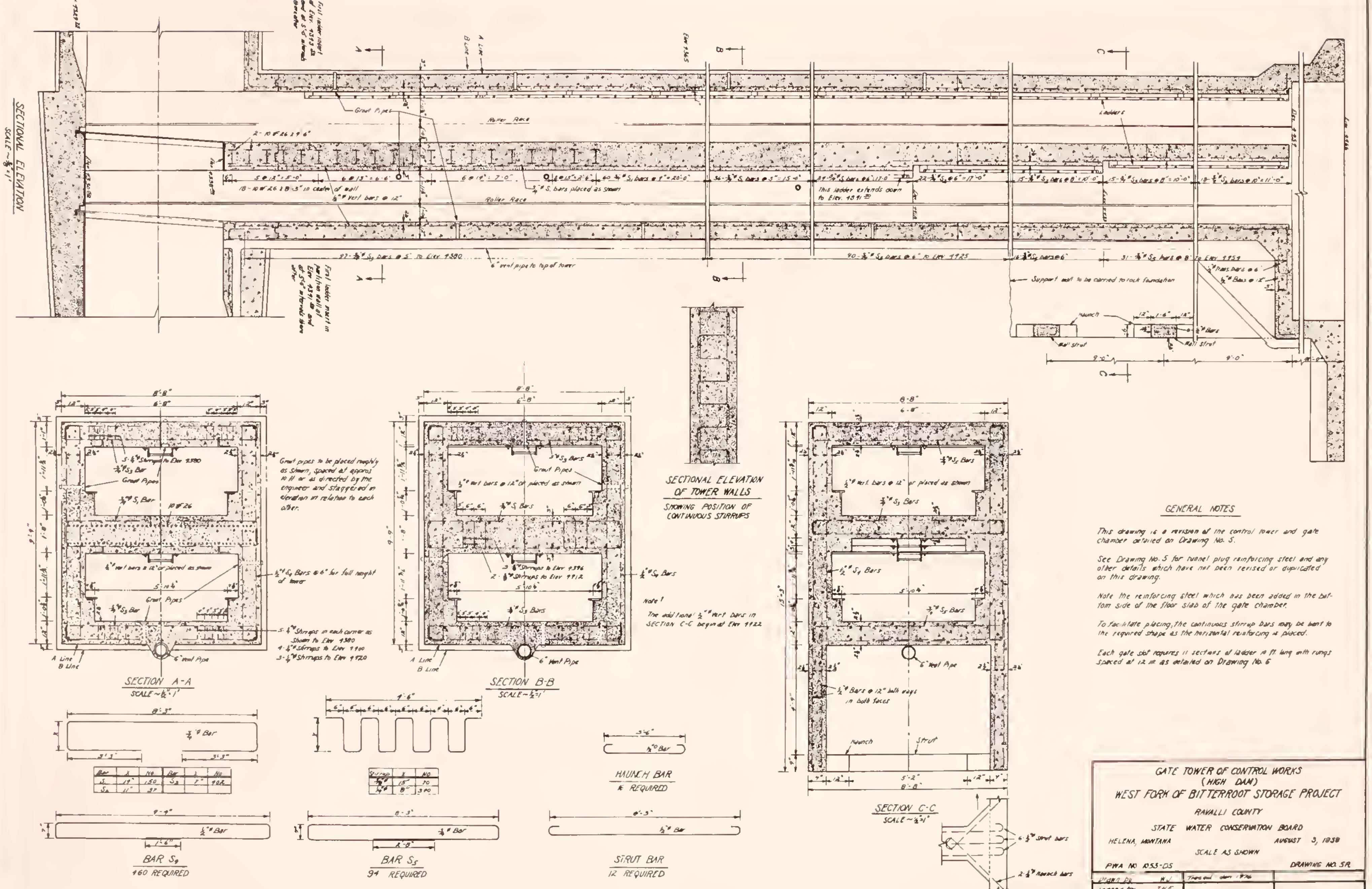
HELENA, MONT. FEB. 12, 1939

SCALE AS SHOWN

P.W.A. NO. 1053-DS DWG. NO 4 OF 11

Drawn by	W.K.J.	Revised April 1939	W.V.J.		
Traced by	W.M.	Approved			

EE-2576



SECTIONAL ELEVATION
SCALE ~ 1/8"=1'

SECTION A-A
SCALE ~ 1/2"=1'

Grout pipes to be placed roughly as shown, spaced at approx 10 ft or as directed by the engineer and staggered in elevation in relation to each other.

1/2" S4 Bars @ 6" for full height of tower

5-1/2" Stirrups in each corner as shown to Elev 4380
4-1/2" Stirrups to Elev 4400
3-1/2" Stirrups to Elev 4420

SECTION B-B
SCALE ~ 1/2"=1'

SECTIONAL ELEVATION OF TOWER WALLS
SHOWING POSITION OF CONTINUOUS STIRRUPS

Note 1
The additional 1/2" vert bars in SECTION C-C begin at Elev 4922

SECTION C-C
SCALE ~ 1/2"=1'

Bar	X	No	Bar	X	No
S_1	19"	150	S_3	7"	902
S_6	11"	97			

Stirrup	X	No
3/4"	15"	70
1/2"	8"	390

BAR S_9
460 REQUIRED

BAR S_5
94 REQUIRED

HAUNCH BAR
[illegible] REQUIRED

STRUT BAR
12 REQUIRED

GENERAL NOTES

This drawing is a revision of the control tower and gate chamber detailed on Drawing No. 5.

See Drawing No. 5 for tunnel plug reinforcing steel and any other details which have not been revised or duplicated on this drawing.

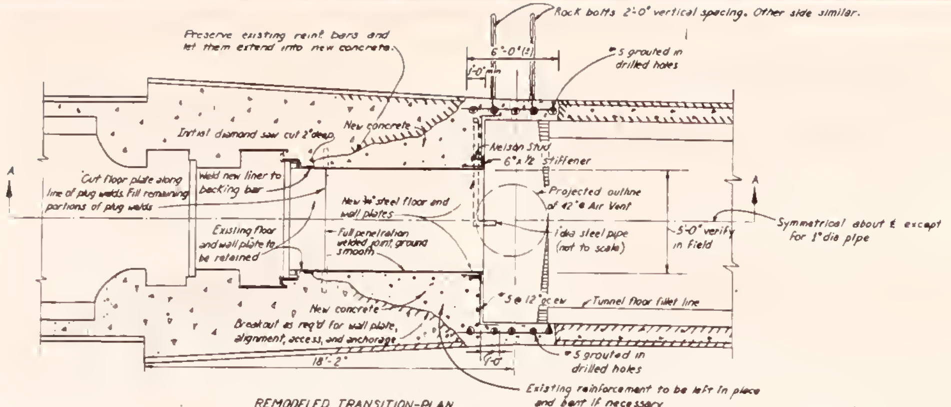
Note the reinforcing steel which has been added in the bottom side of the floor slab of the gate chamber.

To facilitate placing, the continuous stirrup bars may be bent to the required shape as the horizontal reinforcing is placed.

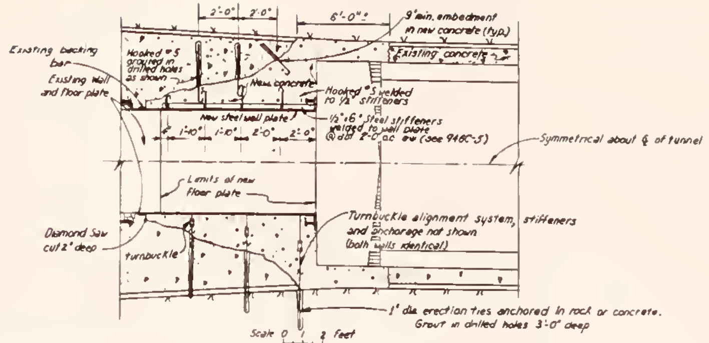
Each gate slot requires 11 sections of ladder 10 ft. long with rungs spaced at 12 in. as detailed on Drawing No. 6

GATE TOWER OF CONTROL WORKS
(HIGH DAM)
WEST FORK OF BITTERROOT STORAGE PROJECT
RAVALLI COUNTY
STATE WATER CONSERVATION BOARD
HELENA, MONTANA AUGUST 3, 1938
SCALE AS SHOWN
PWA NO 1053-DS DRAWING NO. 5R

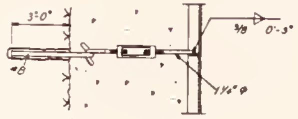
Drawn by H.J.	Traced Jan 1936	
Traced by T.H.F.		


Rock bolts 2'-0" vertical spacing. Other side similar.
Preserve existing reinf. bars and let them extend into new concrete.
6'-0"(±)
1'-0" min
#5 grouted in drilled holes
Initial diamond saw cut 2" deep
New concrete
Nelson Stud
6"x½ stiffener
Cut floor plate along line of plug welds. Fill remaining portions of plug welds
Weld new liner to backing bar
New ⅜" steel floor and wall plates
Projected outline of 42"⌀ Air Vent
Existing floor and wall plate to be retained
Full penetration welded joint, ground smooth
1" dia steel pipe (not to scale)
5'-0" verify in Field
Symmetrical about ℄ except for 1" dia pipe
A
A
#5 @ 12" oc ew
Tunnel floor fillet line
New concrete
Breakout as req'd for wall plate, alignment, access, and anchorage
18'-2"
1'-0"
#5 grouted in drilled holes
Existing reinforcement to be left in place and bent if necessary

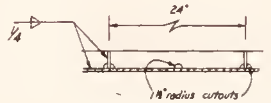
REMODELED TRANSITION-PLAN
(Details and Concrete Anchorage Not Shown)
Scale 0 3 Feet


2'-0"
2'-0"
6'-0"±
9" min. embedment in new concrete (typ.)
Existing backing bar
Hooked #5 grouted in drilled holes as shown
Existing wall and floor plate
New concrete
Existing concrete
Hooked #5 welded to ½" stiffeners
New steel wall plate
½"x6" Steel stiffeners welded to wall plate @ abt 2'-0" oc ew (see 946C-5)
1'-10"
1'-10"
2'-0"
2'-0"
Symmetrical about ℄ of tunnel
Limits of new floor plate
Diamond Saw cut 2" deep
turnbuckle
Turnbuckle alignment system, stiffeners and anchorage not shown (both walls identical)
1" dia erection ties anchored in rock or concrete. Grout in drilled holes 3'-0" deep
Scale 0 1 2 Feet

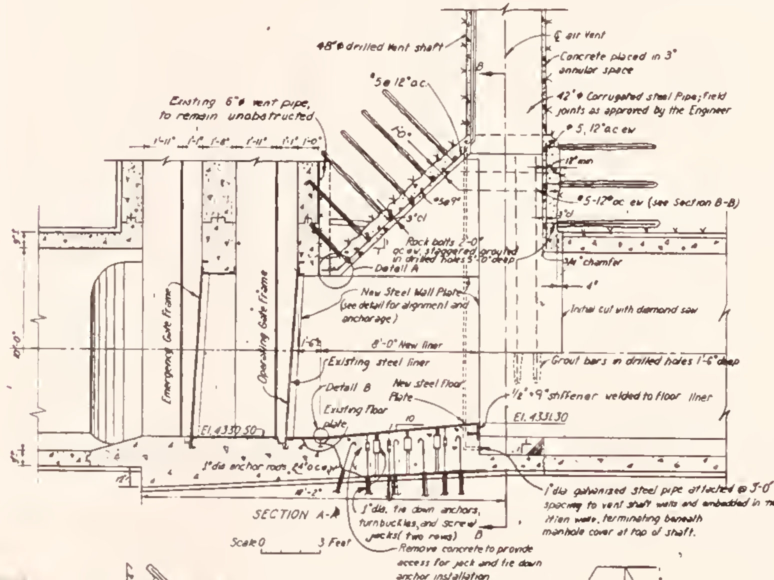
WALL ANCHORAGE AND STEEL LINER
(For steel liner details see Dwg 946C-5)



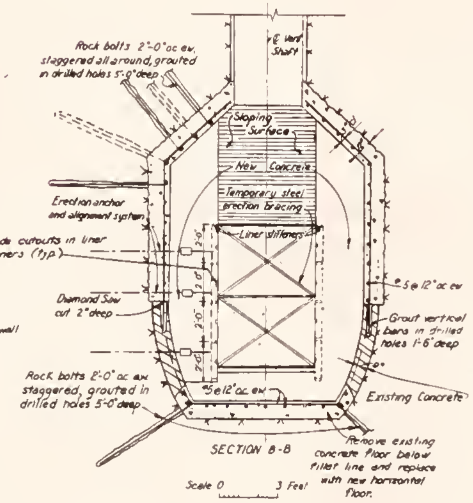
Turnbuckle Anchorage



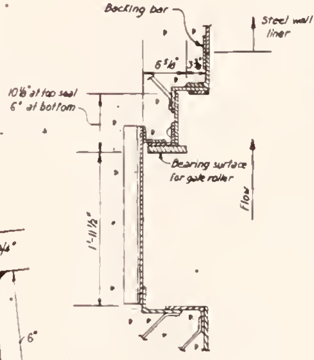
Stiffener Cutouts


48"⌀ drilled vent shaft
℄ air vent
Concrete placed in 3" annular space
42"⌀ Corrugated steel Pipe; field joints as approved by the Engineer
#5 @ 12" ac
Existing 6"⌀ vent pipe, to remain unobstructed
#5, 12" ac ew
18" min
#5-12" oc ew (see Section B-B)
1'-11"
1'-1"
1'-8"
1'-11"
1'-1"
1'-0"
#5 @ 9"
Rock bolts 2'-0" oc ev, staggered, grouted in drilled holes 5'-0" deep
Detail A
¾" chamfer
4"
New Steel Wall Plate (see detail for alignment and anchorage)
Initial cut with diamond saw
Emergency Gate Frame
Operating Gate Frame
8'-0" New liner
10'-0"
Existing steel liner
Grout bars in drilled holes 1'-6" deep
Detail B
New steel floor plate
Existing floor plate
½"x9" stiffener welded to floor liner
El. 4330.50
El. 4331.30
10
1" dia anchor rods, 2'-0" oc ew
18'-2"
1" dia galvanized steel pipe attached @ 3'-0" spacing to vent shaft walls and embedded in transition walls, terminating beneath manhole cover at top of shaft.
1" dia. tie down anchors, turnbuckles, and screw jacks (two rows)
Remove concrete to provide access for jack and tie down anchor installation
B
B

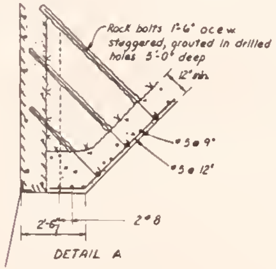
SECTION A-A
Scale 0 3 Feet


℄ Vent Shaft
Rock bolts 2'-0" oc ev, staggered all around, grouted in drilled holes 5'-0" deep
Sloping Surface
New Concrete
Temporary steel erection bracing
Liner stiffeners
Erection anchor and alignment system
Provide cutouts in liner stiffeners (typ)
Diamond Saw cut 2" deep
#5 @ 12" oc ew
Grout vertical bars in drilled holes 1'-6" deep
2'-0"
2'-0"
2'-0"
Rock bolts 2'-0" oc ew staggered, grouted in drilled holes 5'-0" deep
#5 @ 12" oc ew
Existing Concrete
Remove existing concrete floor below fillet line and replace with new horizontal floor.

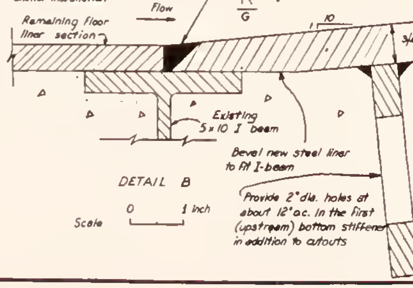
SECTION B-B
Scale 0 3 Feet



DETAIL OF GATE FRAME
Scale 0 1 Foot


Rock bolts 1'-6" oc ew staggered, grouted in drilled holes 5'-0" deep
12" min.
#5 @ 9"
#5 @ 12"
2'-6"
2 #8

DETAIL A
Scale 0 1 2 Feet


Flow
G
10
¾
Remaining floor liner section
Existing 5x10 I beam
6"
Bevel new steel liner to fit I-beam
Provide 2" dia. holes at about 12" ac. in the first (upstream) bottom stiffener in addition to cutouts

DETAIL B
Scale 0 1 Inch

NOTES

1. Seams in wall and floor plates between new and existing steel liner shall be welded with full penetration V welds The finished welds shall be ground smooth.
2. All other welds shall be ¼" fillet welds unless noted on the drawings or otherwise directed.
3. Insets or offsets in existing plug welds shall be filled or ground smooth as directed by the Engineer
4. Rock bolts shall be 1"⌀ hollow, groutable reinforcing bars connected to hooked bars with threaded couplers
5. Liner plates shall be shop assembled to check fit of plates and dimensions before shipping. Erection bracing shall be bolted to gusset plates or angles tack welded to liner sections All tack welds shall be ground smooth after concreting the liner.
6. All existing and new parts to be welded shall be cleaned of rust before welding.
7. See Specification for tolerances
8. Do not paint any metals.
9. Contractor shall check dimensions and geometry of existing steel liner before detailing or fabricating new liner.
10. Steel liner erection scheme shown (bracing, screw jacks, turnbuckles) represent min. req'd. The Contractor can propose improvements to assure proper alignment and support during concreting, for which he is responsible.
11. After the Contractor has poured concrete behind the steel tunnel liner he shall inject a non-shrink grout through the liner to plug any gaps between the liner and concrete due to shrinkage during curing.

MONTANA PROFESSIONAL ENGINEER'S LICENSE No 4917 E

JACK C JONES

MONTANA DEPARTMENT OF NATURAL
RESOURCES AND CONSERVATION

PAINTED ROCKS DAM OUTLET	MODIFICATIONS

REMODELED TUNNEL
SECTIONS AND DETAILS

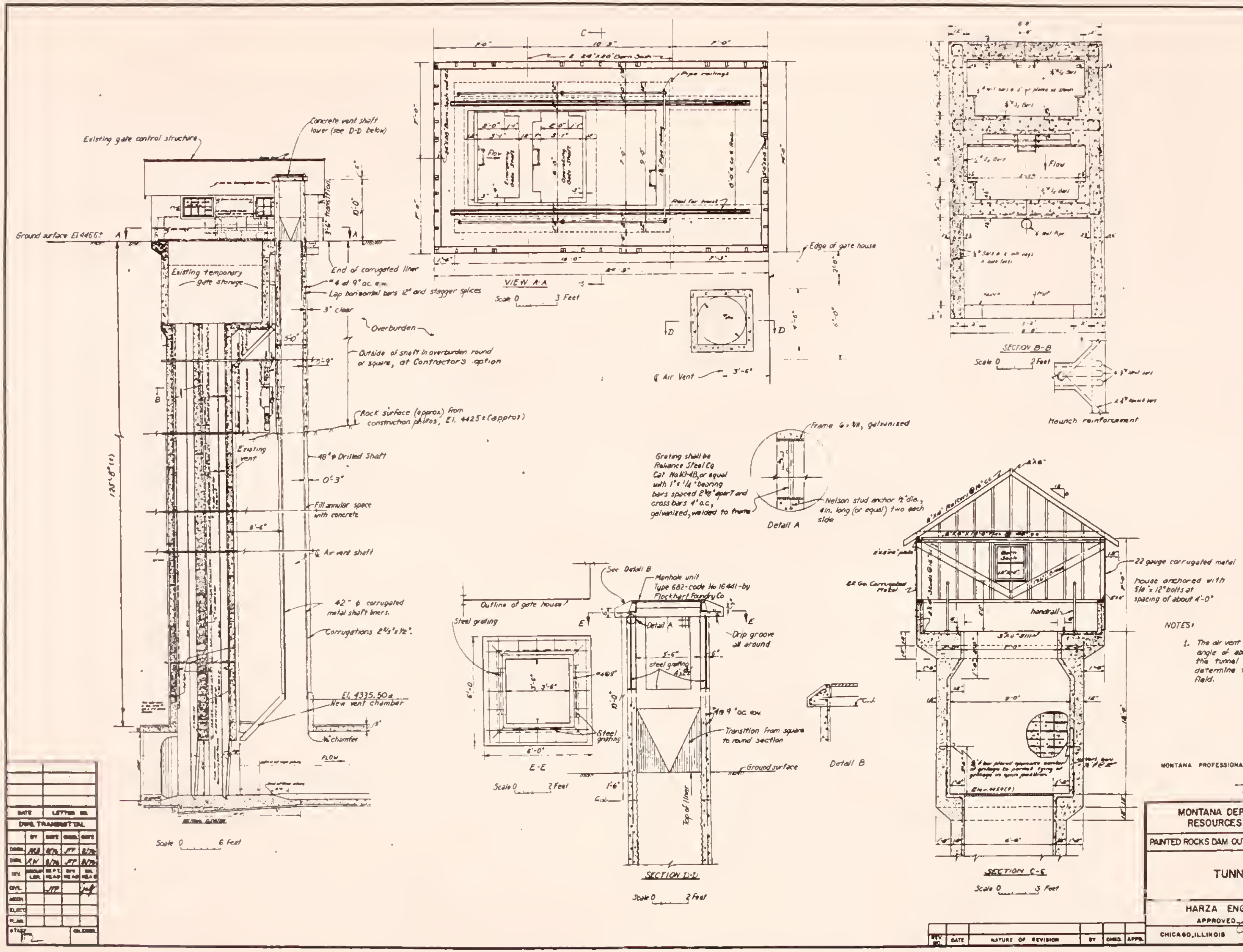
HARZA ENGINEERING COMPANY
APPROVED Jack C Jones
CHICAGO, ILLINOIS
DATE SEPT 1976
DWG. NO. 946 G-4

5-257-41

REV. NO.	DATE	NATURE OF REVISION	BY	CHKD.	APPD.

DATE	LETTER NO.
DWG. TRANSMITTAL	

	BY	DATE	CHKD.	DATE
DSGN.	DRB	8/76	JTP	8/76
DWN.	JTP	8/76	JTP	8/76
DIV.	GROUP LDR.	DEPT. HEAD	DIV HEAD	SR. HEAD
CIVIL		JTP		
MECH.				
ELECT.				
PLAN				
STAFF			CH. ENGR.	


Existing gate control structure
Concrete vent shaft tower (see D-D below)
Ground surface El 4466±
3'-6" transition
10'-0"
End of corrugated liner
Existing temporary gate storage
#4 at 9" o.c. e.w.
Lap horizontal bars 12" and stagger splices
3" clear
Overburden
5'-0"
Outside of shaft in overburden round or square, at Contractor's option
2'-9"
Rock surface (approx.) from construction photos, El. 4425± (approx)
Existing vent
48" φ Drilled Shaft
0'-3"
Fill annular space with concrete
4'-6"
Air vent shaft
42" φ corrugated metal shaft liners.
Corrugations 2 2/3" x 1/2".
El. 4335.50±
New vent chamber
3/4" chamfer
FLOW
125'-6" (±)
Scale 0 6 Feet
VIEW A-A
Scale 0 3 Feet
Pipe railings
Flow
Emergency Gate Shaft
Operating Gate Shaft
Edge of gate house
Air Vent
3'-6"
SECTION B-B
Scale 0 2 Feet
Flow
Haunch reinforcement
Frame 6 x 3/8, galvanized
Grating shall be Reliance Steel Co. Cat. No K3-4B, or equal with 1" x 1/4" bearing bars spaced 2 3/8" apart and cross bars 4" o.c., galvanized, welded to frame
Nelson stud anchor 1/2" dia., 4 in. long (or equal) two each side
Detail A
See Detail B
Manhole unit Type 682-code No 16441-by Flockhart Foundry Co
Outline of gate house
Steel grating
Detail A
Drip groove all around
5'-6"
steel grating
3'-6"
6'-0"
#4 @ 9" o.c. e.w.
Transition from square to round section
Steel grating
Ground surface
Top of liner
E-E
Scale 0 2 Feet
SECTION D-D
Scale 0 2 Feet
Detail B
22 gauge corrugated metal
house anchored with 5/8" x 12" bolts at spacing of about 4'-0"
22 Ga. Corrugated Metal
handrail
Section C-C
Scale 0 3 Feet

NOTES:

1. The air vent shaft must be inclined at an angle of about 5.42° from vertical to intersect the tunnel crown. The Contractor shall determine the exact angle required in the field.

MONTANA PROFESSIONAL ENGINEER'S LICENSE No 4917 E

JACK C. JONES

MONTANA DEPARTMENT OF NATURAL RESOURCES AND CONSERVATION

PAINTED ROCKS DAM OUTLET | MODIFICATIONS

TUNNEL VENT SHAFT

HARZA ENGINEERING COMPANY

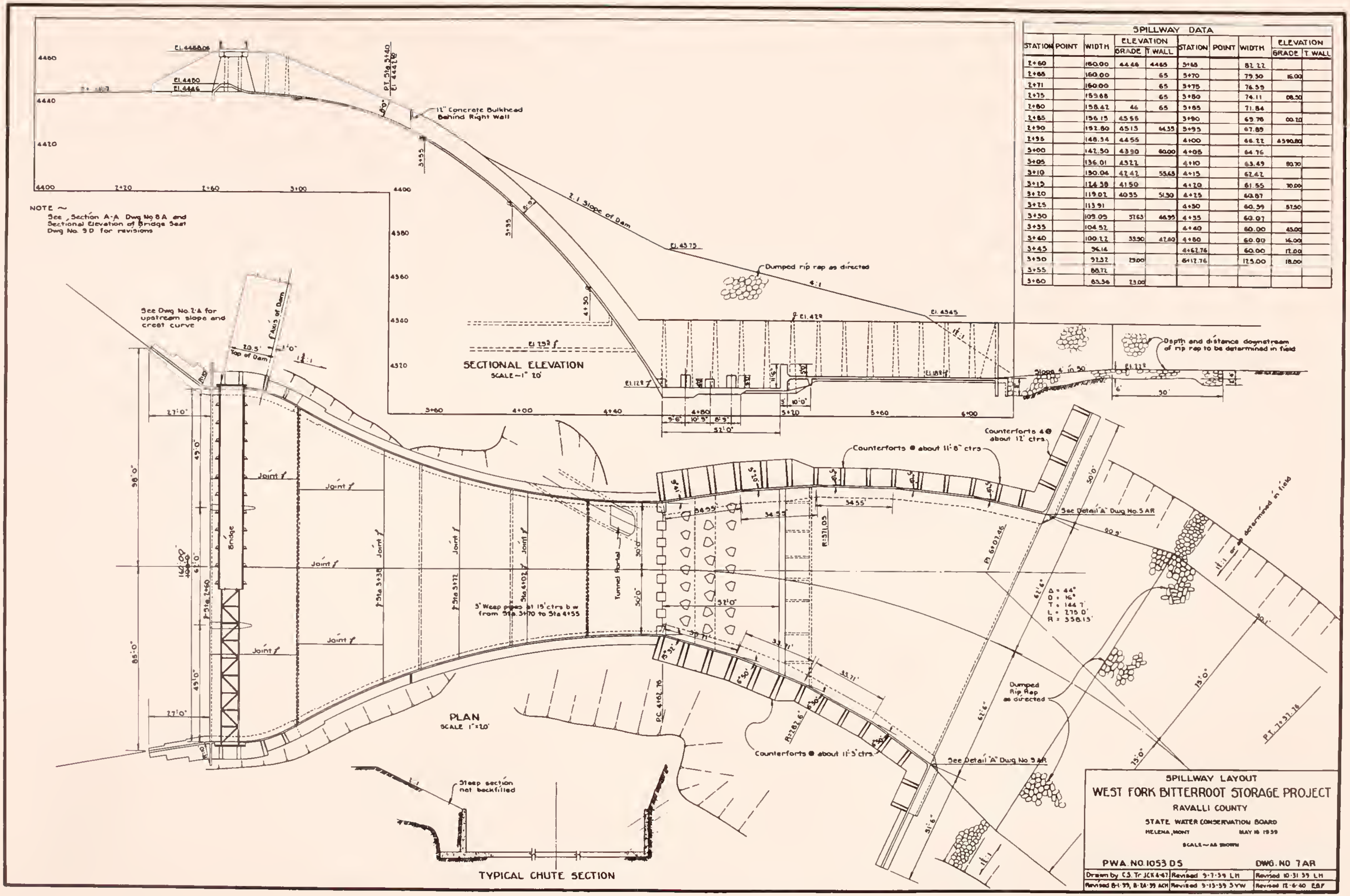
APPROVED Jack C. Jones

CHICAGO, ILLINOIS

DATE SEPT 1976

DWG NO 946 G- 3

5-257-40


El. 4468.06
El. 4450
El. 4446
P.T. Sta. 3+40 El. 4442.0
12" Concrete Bulkhead Behind Right Wall
3+55
3+95
2:1 Slope of Dam
El. 4373
Dumped rip rap as directed
4:1
4+50
El. 4345
El. 4329
El. 4293
SECTIONAL ELEVATION
SCALE ~ 1" 20'
El. 4319
El. 4318
El. 4331
Slope 4' in 50'
Depth and distance downstream of rip rap to be determined in field
52'0"
10'0"
30'
4460
4440
4420
4400
4380
4360
4340
4320
2+20
2+60
3+00
3+60
4+00
4+40
5+20
5+60
6+00
See Dwg No. 2-A for upstream slope and crest curve
Axis of Dam
Top of Dam
Bridge
Joint
3" Weep pipes at 15' ctrs b.w. from Sta. 3+70 to Sta. 4+55
Tunnel Portal
Counterforts @ about 11'-8" ctrs
Counterforts 4 @ about 12' ctrs
See Detail "A" Dwg No. 5 AR
P.I. 6+02.46
Δ = 44°
D = 16°
T = 144.7'
L = 275.0'
R = 358.13'
Dumped Rip Rap as directed
Counterforts @ about 11'-3" ctrs
See Detail "A" Dwg No. 5 AR
P.T. 7+37.36
P.C. 4+62.76
R = 371.05
R = 282.6'
Sta. 2+60
Sta. 3+38
Sta. 3+72
Sta. 4+02
PLAN
SCALE 1" = 20'
Steep section not backfilled
TYPICAL CHUTE SECTION

NOTE ~
See Section A-A Dwg No 8 A and Sectional Elevation of Bridge Seat Dwg No. 9 D for revisions

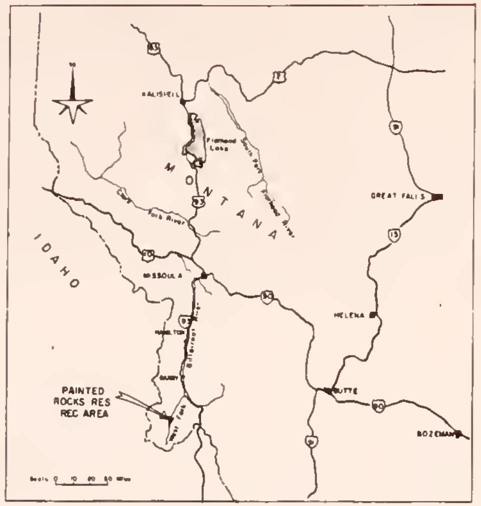
SPILLWAY DATA

STATION	POINT	WIDTH	ELEVATION		STATION	POINT	WIDTH	ELEVATION	
			GRADE	T. WALL				GRADE	T. WALL
2+60		160.00	4446	4465	3+65		82.22		
2+65		160.00		65	3+70		79.50	16.00	
2+71		160.00		65	3+75		76.59		
2+75		159.68		65	3+80		74.11	08.50	
2+80		158.42	46	65	3+85		71.84		
2+85		156.15	4556		3+90		69.76	00.20	
2+90		152.80	4513	64.35	3+95		67.89		
2+95		148.34	4456		4+00		66.22	4590.80	
3+00		142.30	4390	60.00	4+05		64.76		
3+05		136.01	4322		4+10		63.49	80.70	
3+10		130.04	42.42	55.65	4+15		62.42		
3+15		124.38	4150		4+20		61.55	70.00	
3+20		119.02	4055	51.30	4+25		60.87		
3+25		113.91			4+30		60.39	57.50	
3+30		109.05	37.63	46.95	4+35		60.07		
3+35		104.52			4+40		60.00	45.00	
3+40		100.22	33.30	42.60	4+60		60.00	16.00	
3+45		96.14			4+62.76		60.00	12.00	
3+50		92.32	29.00		6+12.76		125.00	18.00	
3+55		88.72							
3+60		85.36	23.00						

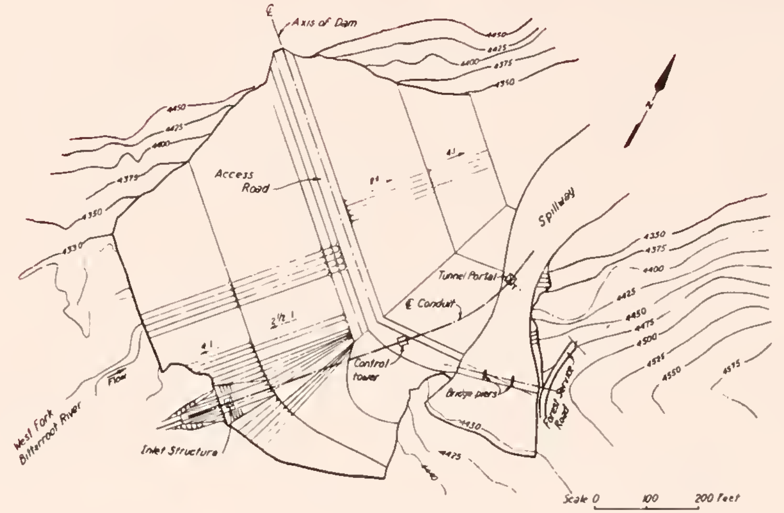
SPILLWAY LAYOUT
WEST FORK BITTERROOT STORAGE PROJECT
RAVALLI COUNTY
STATE WATER CONSERVATION BOARD
HELENA, MONT
MAY 10 1939
SCALE ~ AS SHOWN

PWA. NO. 1053 DS
DWG. NO 7AR

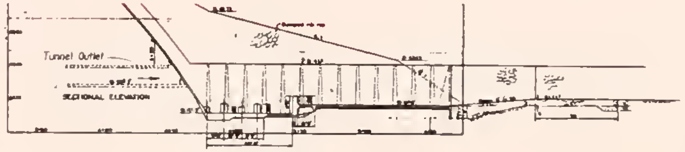
Drawn by C.S. Tr. JCK 4-67	Revised 9-7-39 LH	Revised 10-31-39 LH
Revised 8-1-39, 8-24-39 ACH	Revised 9-13-39 SVW	Revised 12-6-40 E.B.F



KEY MAP

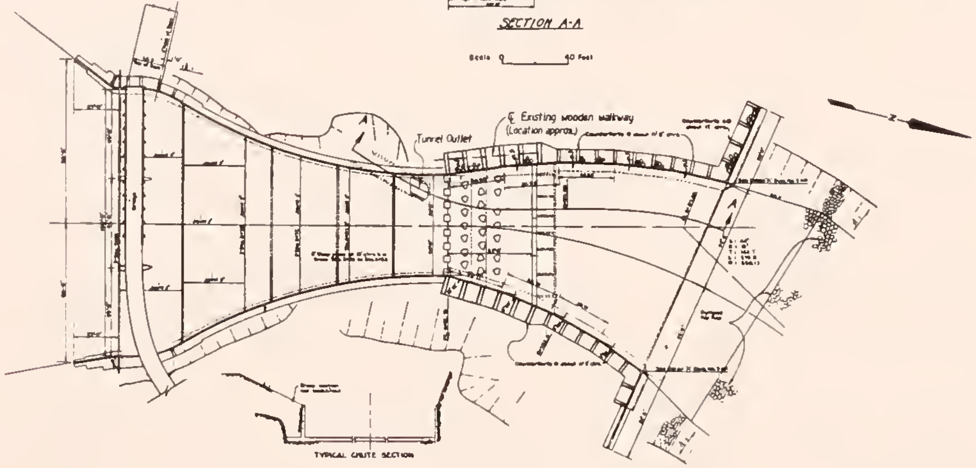


SITE PLAN



SECTION A-A

Scale 0 40 Feet



SPILLWAY PLAN

DATE	LETTER NO.			
DWG. TRANSMITTAL				
	BY	DATE	CHKD.	DATE
DSGN.	DRB	8/76	JTP	8/76
DRN.	DRB	8/76	JTP	8/76
DIV.	GROUP LDR.	DEPT. HEAD	DIV. HEAD	BR. HEAD
CIVIL		JTP		JCJ
MECH.				
ELECT.				
PLAN.				
STAFF			CH. ENGR.	

MONTANA PROFESSIONAL ENGINEER'S LICENSE No 4917 E

JACK C JONES

MONTANA DEPARTMENT OF NATURAL RESOURCES AND CONSERVATION

PAINTED ROCKS DAM OUTLET MODIFICATIONS

LOCATION AND ACCESS

HARZA ENGINEERING COMPANY
APPROVED Jack C. Jones
CHICAGO, ILLINOIS
DATE SEPT 1976
DWG. NO. 946 G-1

REV. NO.	DATE	NATURE OF REVISION	BY	CHKD.	APPD.

5-257-58